Haigh Huddleston & Associates
Civil & Structural Engineering Consultants
Firth Buildings, 99 -101 Leeds Road, Dewsbury, WF12 7BU
t 01924 464342 f 01924 450662 e martin@haighhuddleston.co.uk

Geo-environmental
Ground Investigation Report

ON

PROPOSED RESIDENTIAL DEVELOPMENT

AT

PENNINE VIEW, DARTON

FOR

BARRATT & DAVID WILSON HOMES

JULY 2021

E21/7786/R001

INDEX

0.0 EXECUTIVE SUMMARY

SITE

The site is located land to the north of Pennine View, Darton. The site consists of a field used for crop farming. Yorkshire Water adopted Foul and Surface water sewers run from north to south along the western boundary of the site. The surface water sewer outfalls to a culverted watercourse approximately midway along the western boundary of the site.
The site generally falls from a high point of 142.0m AOD in the northeast to a low point of 130.5m AOD in the southwest at an average grade of 1 in 13.

HISTORY

The site has been shown as undeveloped since the earliest OS plan from 1854. Residential development adjacent the northern, eastern and southern boundaries began in the 1930s.

GEOLOGY

The northern half of the site is shown as an area of infilled ground. This coincides with the historical opencast mine recorded on site.
The site is underlain by the Pennine Middle Coal Measures Formation, consisting of Mudstone, Siltstone and Sandstone.
Fault lines are shown running along the south eastern boundary of the site, and crossing the north western corner of the site.
In the northern half of the site, in the former opencast mine, a thin layer of topsoil overlying fill up to 8.1m in depth was encountered. Alternating bands of mudstone, siltstone and sandstone were encountered beneath the base of the opencast.
In the southern half of the site, a relatively shallow depth of clay overlaid alternating bands of mudstone, siltstone and sandstone.

MINING/QUARRYING

The Coal Authority Report states that the property is in a surface area that could be affected by underground mining in 10 seams of coal at 40m to 490m depth, and last worked in 1987. Additionally, historical opencast mining has been undertaken in the northern half of the site.
Three coal seams were encountered at shallow depths beneath the site.
The upper coal seam is 0.9-1.0m thick and outcrops halfway through the site, this has been worked via opencast methods in the north of the site.
A second 0.9-1.0m thick coal seam was encountered at 3.8-8.5m below ground levels in the south of the site and 12.8-17.2m below ground levels in the northern half.
A third 0.4m thick coal seam was encountered at 21.3-21.7m below existing ground levels at the lower southern end of the site.
None of the coal seams showed evidence of being worked beyond the opencast workings in the north of the site.

HYDROLOGY	An un-named open watercourse flows westwards from the western site boundary. A culvert watercourse flows southwards from midway up the western boundary. The site is not located within any Environment Agency defined flood zones or shown to be at risk of flooding from rivers or the sea.
HYDROGEOLOGY	The groundwater vulnerability map for the area indicates that the site overlies rocks designated as a Secondary (A) aquifer. No groundwater was recorded during the trial pit excavations or rotary borehole investigation. Groundwater was recorded at depths of 1.9-3.6m below existing ground levels during the gas monitoring.
HAZARDOUS GAS	The property is not in an area requiring radon protection measures. Gas monitoring has been undertaken on two occasions to date and recorded no methane and a maximum carbon dioxide concentration of 4.9%. Due to the low carbon dioxide levels and flow rates encountered, we would recommend the gas regime on this site be currently classified as Green by the NHBC traffic light system, or CS1 by BS 8485:2015 Table 2.
CONTAMINATION	No elevated levels of heavy or phytotoxic metals or PAH compounds were recorded in the samples from site. No asbestos was recorded in the samples taken from site.
REMEDIATION	The topsoil on site has proved clean from contamination. We would recommend that the topsoil is scraped and screened to remove unsuitable material and then stockpiled behind protective fencing for eventual re-use on site to soft landscaped areas.
FOUNDATIONS	Due to the depth of infill within the former opencast mine in the north of the site, it is recommended that piled foundations are used in this location. For the remainder of the site, strip/trench fill foundations to the underlying clay or mudstone strata may be used. Where the shallow coal seam is encountered, the foundations should be taken through to the underlying natural strata.
DRAINAGE	Infiltration methods have proved unsuitable for use on site. A discharge rate must be agreed with Barnsley MBC Lead Local Flood Authority.

1.0 INTRODUCTION

1.1 As requested by Barratt & David Wilson Homes, this practice carried out ground and contamination investigation works for a proposed development on land off Pennine View, Darton.

1.2 The purpose of the report was to:-

1.2.1 Identify the nature of the near surface strata, in order to enable recommendations to be made as to the most economic foundation solution for the proposed residential development.

1.2.2 To identify any areas of contaminated ground.

1.2.3 Propose a suitable outline remediation strategy, which will enable the site to be developed safely, to the satisfaction of the overseeing regulators and in compliance with the current environmental standards.

1.2.4 Determine if historical opencast and shallow mine workings would adversely affect the site.

1.2.5 Determine if ground gas migration from historical mine workings would adversely affect the site.

1.2.6 Determine if infiltration methods would be a suitable form of surface water dispersal.

1.3 Soil sampling was undertaken via trial pits to determine the near surface strata. Distributed samples were taken for testing to ascertain the nature of the soils and fills present.

1.4 The conclusions and recommendations made in this report are limited to the findings of the preliminary Geotechnical Survey. The report is made on condition that Haigh Huddleston Associates will not in any circumstances be liable for loss, arising directly or indirectly from ground conditions encountered between trial pits and boreholes, which have not been revealed by the investigation.

1.5 Any opinion given on the possible configuration of strata between trial pit and borehole locations and below maximum depth of the investigation is for guidance only. Any remarks on groundwater conditions made are based solely on observations made at the time of investigation. Kindly note that levels may differ from those reported due to seasonal variations or other influences.

1.6 Furthermore, there is the possibility that any trial pits or boreholes undertaken as part of the investigatory works may be within the influence of existing or proposed foundations or excavations. Haigh Huddleston Associates cannot be held responsible for any failure of any excavations, foundations, or structures within the influence of the trial pits or boreholes.

2.0 THE SITE

2.1 The site is located on land to the northern end of Pennine View, Darton and lies around OS Grid Reference 432179, 410860. A site location plan is attached in Appendix A at the rear of the report.

2.2 The site is approximately square in shape, with the northern, southern and eastern boundaries formed by the rear gardens to residential properties. To the west and southwest there are further fields. Access to the site is through a farm off Coniston Avenue to the North of the site. Proposed access to the site is from Pennine View on the southern boundary of the site, this is currently fenced off.

2.3 The site consists of a field used for crop farming. A second field proposed for proposed surface attenuation is located to the southwest and is separated from the main field by a hedge. Yorkshire Water adopted Foul and Surface water sewers run from north to south along the western boundary of the site. The surface water sewer outfalls to a culverted watercourse approximately midway along the western boundary of the site.

2.4 The site is open to further fields on the western boundary. There is a hedge separating the field from the adjacent residential properties to the north, south and east. Occasional mature trees are noted to the corners of the site.

2.5 The site generally falls from a high point of 142.0m AOD in the northeast to a low point of 130.5m AOD in the southwest at an average grade of 1 in 13.

3.0 SITE HISTORY

A number of historical Ordnance Survey plans from 1854-2021 have been consulted. These are contained for reference within Appendix C to the rear of the report. Below is a brief description outlining the significant developments that may affect future construction of the site.

Date	Historical uses on site	Historical findings within 100m perimeter of the site	Historical findings further than 100m perimeter of the site
1854	i) The area to be developed is shown as open field.	i) Darton Lane runs southwest to northeast 50m east of the site.	i) Sandstone quarries 200m east and 475m south of the site. ii) Old coal pit 400m south east of the site.
1891	i) The on-site features are similar to the previous sheet.	i) Residential development 50m east of the site.	i) Wheatley Wood Colliery 750m north of the site. ii) Woolley Colliery 1000m to the west. iii) Sandstone quarries no longer labelled.
1904-1930	i) The on-site features are similar to the previous sheet.	i) Works and gas hook 70m east of site.	i) Reservoir 200m east of site. ii) Old coal shaft 300m northeast of site.
1938-1948	i) The on-site features are similar to the previous sheet.	i) Residential properties constructed east and northeast of site.	i) No significant developments further than 100m from site.
1951-1978	i) The on-site features are similar to the previous sheet.	i) Residential development immediately north of site. ii) Drain shown heading westwards from western boundary.	i) Wheatley Wood Colliery shown as disused.
1990-1993	i) The on-site features are similar to the previous sheet.	i) Residential development immediately south of site.	i) No significant developments further than 100m from site.
2001	i) The on-site features are similar to the previous sheet.	i) Properties immediately adjacent north western corner of the site no longer shown.	i) No significant developments further than 100m from site.
2010-2020	i) The on-site features are similar to the previous sheet.	i) No significant developments within 100m of the site.	i) Woolley colliery now shown as a residential estate.

4.0 SITE GEOLOGY & MINING

4.1 The BGS Digital Geological map of Great Britain at 1:10,000 has been consulted and we would report as follows:-

4.2 The northern half of the site is shown as an area of infilled ground. This coincides with the historical opencast mine recorded on site.

4.3 No superficial strata is shown overlying the site.

4.4 The site is underlain by the Pennine Middle Coal Measures Formation, consisting of Mudstone, Siltstone and Sandstone.

4.5 There are two faults shown crossing the site. The first crosses the north western corner of the site from south west to north east. The second fault line runs south west to north east along the south eastern boundary of the site. The recorded location of the fault lines is indicated on the site investigation plan in Appendix A.

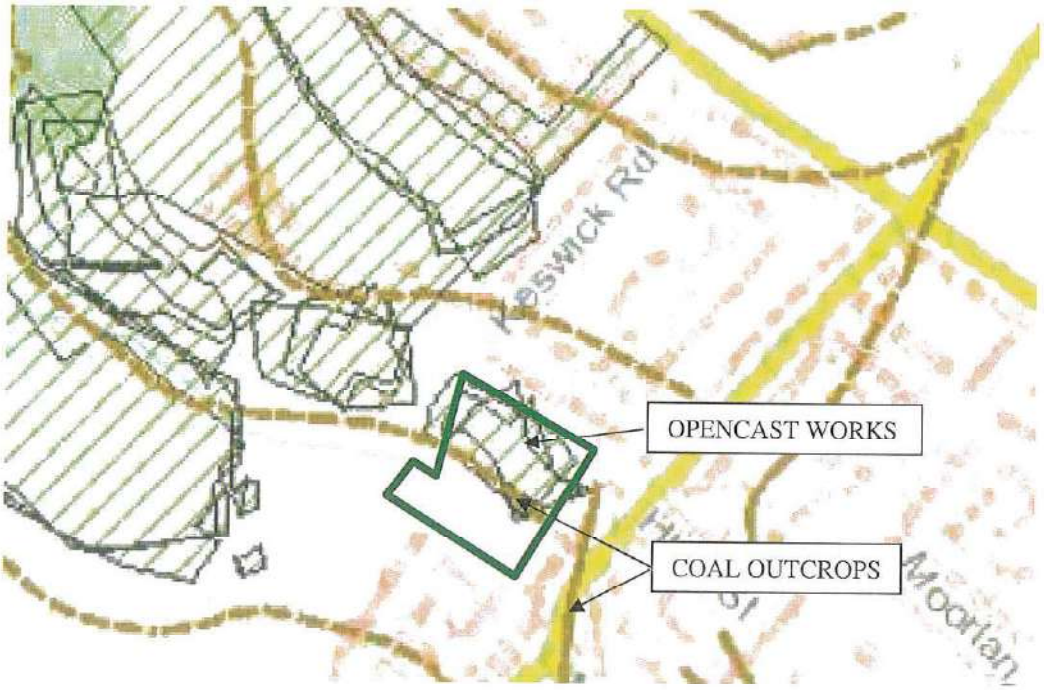
4.6 Additionally, South Yorkshire Mining Advisory Service have confirmed that several properties on Coniston Avenue to the north west of the site had to be demolished due to structural instability from movement within this fault line. The fault movement was initiated by deep mining subsidence. However, all deep mining has now ceased in the area and therefore the site should be stable in this regard.

4.7 There are no detailed deep BGS boreholes recorded in the vicinity of the site.

4.8 The Coal Authority Report states that the property is in a surface area that could be affected by underground mining in 10 seams of coal at 40m to 490m depth, and last worked in 1987. Any ground movement from these coal workings should have stopped by now.

4.9 In addition to this, the Coal Authority report states that the property is in an area where the Coal Authority believes that there is coal at or close to the surface. Historically, shallow and surface coal has been worked by private individuals and these workings have been unrecorded by the Coal Authority.

4.10 The property is also within the boundary of an opencast site from which coal has been removed by opencast methods. The Coal Authority Interactive Map Viewer indicates the open cast mining to have occupied approximately half of the site.



4.11 The property is not in an area for which the Coal Authority is determining whether to grant a licence to remove coal using underground methods. The property is not in an area for which a licence has been granted to remove or otherwise work coal using underground methods. However, reserves of coal exist in the local area which could be worked at some time in the future.

4.12 There are no known coal mine entries within, or within 20 metres of, the boundary of the property.

4.13 The southwestern corner of the site is shown to belong to a property that has made a subsidence claim. There are two further claims for subsidence located immediately southeast and 40m north of the site. Two claims for subsidence in the vicinity of the site have been rejected.

5.0 ENVIRONMENTAL CONSIDERATIONS

5.1 Radon

The property is in a Radon Affected Area, as between 1 and 3% of properties are above the action level.

No Radon Protective Measures are necessary.

5.2 Landfill Sites

There are no recorded historical landfills within 250m of the site. However, the northern third of the site was a former opencast coal mine and has been infilled with unrecorded materials.

5.3 Flood Risk

The site is not located in a currently defined Environment Agency flood zone or at risk of flooding from rivers and the sea.

5.4 Groundwater

The groundwater vulnerability map for the area indicates that the site overlies bedrock designated as a Secondary (A) aquifer. These are permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

The site is not within a currently defined (Groundwater) Source Protection Zone (SPZ).

There are no licensed groundwater or surface water abstractions within 250m of the site.

There are no Licensed Discharge Consents within 250m of the site.

There are no recorded pollution incidents to controlled waters within 250m of the site.

An un-named open watercourse flows westwards from the western boundary of the site. This is classified as an inland river not influenced by normal tidal action. Additionally, a Yorkshire Water surface water sewer discharges to a former open watercourse in the south west corner of the site. This has been culverted as it heads southwards from the site.

5.5 Designated Environmentally Sensitive Site

The southwestern corner of the site, separate from the main field, is shown to be part of the South and West Yorkshire Green Belt. This is the location of the proposed attenuation basin.

6.0 PRELIMINARY CONCEPTUAL SITE MODEL

6.1 The initial stage in assessing the risks posed from contaminated land during the redevelopment of a site is to prepare a conceptual model. A generalised conceptual model can be developed highlighting the main pollutant linkages through a contaminant ► pathway ►receptor model for a residential development. In order to prepare the conceptual model for a particular site the following parameters need to be reviewed as discussed below.

6.2 Contamination of existing land can be caused by a number of factors, including:-

i) Possible historical/current industrial activities.

ii) Disposal of waste materials.

iii) Storage of materials.

iv) A number of natural processes can also lead to hazardous gases and elevated heavy metals.

6.3 Potential pathways can include ground and surface water, permeable strata, existing services providing a conduit and voided ground. Potential receptors can include human health, ecosystems, controlled waters and building structures. There are a number of ways that a receptor can be exposed to the contaminant these include, inhalation, direct contact, ingestion, dermal contact, and uptake.

6.4 Sources of potential contamination, that could affect the proposed development, from either on or off site activities would include the following:-

i) Infill material to former opencast mine on site.

ii) Possible ground gas migration from opencast and probable shallow mine workings on and in vicinity of site.

Based on the above activities the potential for some contamination to exist on site is considered to be moderate.

6.5 Considering the proposed residential end use, there will be two possible human receptor groups exposed to the existing onsite contamination:-

a) Site operatives during development.

b) End users, future site residents (the critical receptor is a 6 year-old girl).

6.6 Human receptors may be exposed to site contamination by a number of possible pathways. These pathways are summarised in Table 1 below.

Table 1- Potential Human Exposure Pathways

Human Exposure Pathway	Site Residents	Construction Workers
Soil Ingestion	YES	YES
Consumption of Home Grown Vegetables	YES	NO
Dermal Contact	YES	YES
Dust Inhalation	YES	YES
Gases/Vapours	YES	NO

6.7 The construction workers will come into contact with any contaminated soil to a far greater extent than future residents. The exposure pathways are generally through dermal contact and indirect ingestion. However their exposure will be for a limited time and the provision and correct use of personnel protective equipment and adequate welfare facilities during construction should restrict their risks to acceptable levels.

6.8 Future site residents can be protected in the long term development of the site via a suitable remediation strategy that ensures any proposed contaminated materials remaining on-site are suitably isolated beneath an effective capping layer.

6.9 The risk of pollution to controlled waters by existing contamination is considered low. There have been no recorded pollution incidents associated with the site and there has been no development of the site shown since 1854. However, there are watercourses on the western boundary of the site and a temporary works plan will be required to protect the site from surface water run-off containing contaminants during development of the site.

6.10 No specific areas of ecological importance have been identified in the initial desk top study. Therefore the site is considered to be in a low risk environmental setting. The potential for phototoxic materials to exist at shallow depth should be considered, these could pose a potential risk to new planting and soft landscaping areas within the proposed development.

6.11 The proposed planning drawings indicate residential properties with private garden areas and hard paved site access and parking areas. The presence of elevated sulphates and hydrocarbons could affect the long term integrity of buried concrete structures, including foundations and drainage pipes. Plastic water supply pipes can also be damaged by the presence of hydrocarbon contamination.

7.0 FIELDWORK

7.1 Trial pit excavations were undertaken on the 1-3 June 2021 using an 8 tonne tracked 360 excavator equipped with 600mm bucket. A total of fourteen trial pits were undertaken in total, which included two trial trenches. Two of these were used to undertake soakaway testing. In addition to this twenty-eight boreholes were undertaken on site to depths of between 3m and 30m to identify the extents of the opencast workings and determine the presence of shallow of mine workings. Six of the boreholes were fitted with gas monitoring stations to determine if ground gas generation would adversely affect the site, as well as monitoring ground water levels.

7.2 Materials encountered in the trial pits and boreholes were examined and categorised. Trial pit and borehole logs are contained within Appendix B of the report.

7.3 The soakaway tests were undertaken in accordance with the method specified in BRE Digest 365 Soakaway Design. An instantaneous supply of water was provided via a bowser. In general, the trial pits were filled and the water levels were recorded against time as the water permeated into the natural strata. The water level was monitored over an extended time period to determine the infiltration rate for the natural strata.

7.4 The site investigation works were designed to achieve comprehensive site coverage within the proposed development area. These were restricted by the existing sewers adjacent the western boundary and electrical services in the south western corner of the site.

7.5 Soil samples were removed from the natural and made ground deposits within the trial pits. The samples were removed by operatives wearing gloves and placed into airtight clean plastic containers and glass bottles for transportation to the laboratory.

7.6 A total of eleven samples from the natural and made ground deposits were recovered from the trial holes for chemical analysis. The testing was carried out by a UKAS accredited laboratory to nationally or accredited in-house methods. The results of the contamination testing are contained within Appendix C of this report.

7.7 A suite of common potential contaminants consisting of heavy metals, phytotoxic metals, sulphates, sulphides and poly-aromatic hydrocarbons as well as asbestos were analysed for.

7.8 All samples were stored in airtight containers within cool boxes at approximately 4°c until delivery to the laboratory within 48 hours.

8.0 RESULTS OF THE INVESTIGATION

8.1 GEOTECHNICAL INVESTIGATION

8.1.1 A copy of the trial hole and borehole logs providing a complete record of strata encountered beneath the proposed development is presented in Appendix B.

8.1.2 The site can generally be divided into two areas. In the northern half, the trial pits proved infill material to the former opencast mine, while in the south a relatively shallow depth of clays overlaid a mudstone bedrock.

8.1.3 FORMER OPENCAST MINE. (TP03, TP05-TP07, TP10-TP14, BH01, BH01A, BH05H, BH06E, BH06F, BH07, BH10-BH12)

8.1.3.1 The trial pits in this area of the site proved a 0.2-0.3m of topsoil overlying re-engineered clays and mudstones, with occasional bricks and red shale, particularly in TP11 in the northeastern corner of the site. The re-engineered ground extended to the base of all these trial pits except TP12 at the edge of the opencast workings. TP10 was a trial trench undertaken to shallow depth and identified the location of the coal outcrop. TP14 was a trial trench undertaken to shallow depth to determine the location of any high wall features on the western boundary of the opencast.

8.1.3.2 Beneath the re-engineered ground in TP12 and the western half of TP14, a 0.6-0.8m thick layer of firm to stiff light brown clay with occasional mudstone gravels was encountered at 1.1-1.4m below existing ground levels. This in turn was underlain by a weak grey mudstone excavated as shaley gravels and encountered at 1.9-2.5m below existing ground levels and extending to the base of the trial pits. The eastern half of TP14 proved re-engineered ground to the base of the trial pit at 2.6m below existing ground levels, confirming the presence of a high wall feature on the western edge of the opencast works.

8.1.3.3 The boreholes undertaken in this area of the site show a gradual increase in the depth of clay fill/colliery spoil to the north, indicating there are no high wall features and the base of the opencast slopes with the dip of the coal seam extracted. The depth of fill/spoil ranged from 2.7m to 8.1m.

8.1.3.4 Beneath the base of the opencast workings, the boreholes proved bands of mudstone, siltstone and sandstone to a depth of 30m beneath existing ground levels. The boreholes generally proved a second deeper seam of coal 0.9-1.0m thick encountered at 12.8-17.2m below existing ground levels.

8.1.4 REMAINDER OF THE SITE (TP01, TP02, TP04, TP08, TP09, BH02-BH05G, BH06A-BH06D, BH08-BH09)

8.1.4.1 The trial pits in the remainder of the site proved 0.25-0.4m of dark brown topsoil overlying firm to stiff light brown and grey sandy clays with occasional gravels of mudstone. The mudstone gravels were noted to become more numerous with depth. The clay strata varied in thickness from 1.1m to 2.25m across site. In only TP08 in this area of the site was a 0.8m thick layer of re-engineered sandy clays proved beneath the topsoil.

8.1.4.2 Underlying the clay strata, a moderately weak grey mudstone excavated as angular gravels was encountered at 1.4-2.6m below existing ground levels.

8.1.4.3 BH05A-BH05G and BH06A-BH06D were undertaken at the edge of the opencast works. The southernmost boreholes proved up to 2.2m of clay with mudstone encountered beneath. The northernmost boreholes proved up to 2.1m of clay overlying a 0.6-0.7m thick seam of coal, with mudstone bedrock encountered at 2.0-2.8m below existing ground levels.

8.1.4.4 BH02-BH04A and BH08-BH09 were undertaken to the south of where the uppermost coal seam had been outcropped. These proved 0.3-0.4m of topsoil overlying 1.6-2.2m of brown clay. Beneath this in all the boreholes, alternating bands of mudstone, siltstone and sandstone were encountered from 1.9-2.6m below existing ground levels.

8.1.4.5 An intact 0.9-1.0m thick coal seam was encountered in all but BH04 and BH04A at depths of 3.3-8.5m below existing ground levels, getting deeper as the ground rose to the north. In only BH02 a deeper 0.4m thick intact coal seam was encountered at 21.2-21.7m below existing ground levels.

8.1.5 A summary of the strata encountered within the boreholes undertaken across the entire site is presented in Table 2 below:

Table 2 Summary of Strata within boreholes

Borehole No.	Topsoil (m)	Clay (m)	Fill/Colliery Spoil (m)	Mudstone (m)	Rock Cover (m)	Seam 1 (m)	Seam 2 (m)	Seam 3 (m)	10x seam cover
1	-	-	0-8.1	8.1-16.2	8.1	-	16.2-17.2	-	N
1A*	-	-	0-3.0	-	-	-	-	-	-
2	0.0-0.4	0.4-2.5	-	2.5-5.1	2.6	-	5.1-6.0	21.3-21.7	N
3*	0.0-0.4	0.4-2.3	-	2.3-3.3	1.0	-	3.3-4.3	-	N
4	0.0-0.4	0.4-2.6	-	2.6-7.0	>4.4	-	-	-	-
4A*	0.0-0.4	0.4-2.6	-	2.6-3.0	>0.4	-	-	-	-
5A	-	0.0-2.2	-	2.2-6.0	>3.8	-	-	-	-
5B	-	0.0-2.1	-	2.1-6.0	>3.9	-	-	-	-
5C	-	0.0-2.1	-	2.1-6.0	>3.9	-	-	-	-
5D	-	0.0-1.4	-	2.0-3.0	0.0	1.4-2.0	-	-	N
5E	-	0.0-1.4	-	2.0-3.0	0.0	1.4-2.0	-	-	N
5F	-	0.0-1.8	-	2.4-3.0	0.0	1.8-2.4	-	-	N
5G	-	0.0-2.1	-	2.8-6.0	0.0	2.1-2.8	-	-	N
5H	-	0.0-3.0	-	3.0-6.0	>3.0	-	-	-	-
6A	-	0.0-1.0	-	1.6-3.0	0.0	1.0-1.6	-	-	N
6B	-	0.0-1.2	-	1.8-3.0	0.0	1.2-1.8	-	-	N
6C	-	0.0-1.7	-	2.3-3.0	0.0	1.7-2.3	-	-	N
6D	-	0.0-1.8	-	2.4-3.0	0.0	1.8-2.4	-	-	N
6E*	-	-	0.0-2.7	2.7-3.0	-	-	-	-	-
6F	-	-	0.0-3.0	3.0-6.0	-	-	-	-	-
7	-	-	0.0-6.3	6.3-13.2	6.9	-	13.2-14.2	-	N
8	0.0-0.3	0.3-0.9	-	1.9-7.2	5.3	7.2-8.2	-	-	N
8A*	0.0-0.3	0.3-1.9	-	1.9-3.0	-	-	-	-	-
9	0.0-0.3	0.3-2.1	-	2.1-7.5	5.4	7.5-8.5	-	-	N
10	-	-	0.0-6.3	6.3-12.8	6.5	-	12.8-13.8	-	N
11	-	-	0.0-8.0	8.0-16.1	8.1	-	16.1-17.1	-	N
11A*	-	-	0.0-3.0	-	-	-	-	-	-
12	-	-	0.0-2.0	2.0-6.3	4.3	6.3-7.3	16.2-17.1	-	N

8.1.6 Overall, the boreholes indicate three coal seams passing beneath the site. The upper coal seam is 0.9-1.0m thick and outcrops halfway through the site as indicated on the Coal Authority Plans. This has been worked via opencast methods in the north of the site.

8.1.7 A second coal seam has been encountered, within the deeper boreholes, beneath the opencast workings at depths of 12.8-17.2m beneath existing ground levels, and at depths of 3.3-8.5m to the south of the opencast workings. This coal seam was also 0.9-1.0m thick.

8.1.8 A third coal seam was encountered with BH02 in the south of the site. This was the only deep borehole to 30m undertaken at the lower end of the site and proved a 0.4m thick coal seam at 21.3-21.7m below existing ground levels. This would dip northwards below the depth of the remaining deep boreholes undertaken. Sections through the seams are included in Appendix A.

8.1.9 Except the opencast workings associated with the uppermost coal seam in the north of the site, none of the coal seams encountered showed evidence of being extracted.

8.1.10 As discussed previously in the report, two of the trial pits were used to carry out soakaway tests in order to obtain an infiltration rate for the development. This was undertaken in TP01 and TP02 at the lower southern end of the site.

8.1.11 The infiltration rate has been calculated between the 75% and 25% full values as recommended in the BRE Digest 365. The soakaway result in included in Appendix B and is summarised Table 3 below:-

Table 3 Summary of infiltration rates

SOAKAWAY NUMBER	INFILTRATION RATE m/s $x10^{-6}$
TP01	1.3
TP02	ABANDONED DUE TO STATIONARY WATER LEVELS

8.1.12 During the soak-a-way tests, TP01 registered a slight drop in water level over the five hour duration of the test with a low infiltration rate of 1.3×10^{-6} m/s recorded. In TP02 the water level remained stationary during the five hours of the test.

8.1.13 The result of the geotechnical analysis undertaken on the samples of clayey soil indicates the clay to be of intermediate plasticity (Plasticity Index 19-22%). If the modified results are calculated, taking into account the percentage of material

retained on a 425micron sieve, the results correspond to a low shrinkage clay. The test certificates are contained in Appendix C.

8.2 GROUNDWATER

8.2.1 No groundwater was encountered during the trial pit investigation.

8.2.2 No groundwater strikes were recorded during the rotary borehole investigation. Groundwater was recorded at depths of 1.9-3.6m below existing ground levels during the gas monitoring.

8.2.3 It should be recognised that ground water levels may vary throughout the year. During periods of heavy rainfall, the groundwater levels may be substantially higher than the results revealed in these investigations.

8.3 GAS MONITORING

8.3.1 As discussed previously three of the shallow boreholes were installed with gas standpipes and lockable covers. Gas testing is currently being undertaken on site and to-date the wells have been monitored on three occasions following the installation of the standpipes.

8.3.2 A standard gas monitoring procedure has been followed in accordance with CIRIA guidance, including measurement of the following:-

i) Methane, Oxygen and Carbon Dioxide concentrations.
ii) Atmospheric Pressure.
iii) Gas Flow Rate.
iv) Standing water level.

8.3.3 The result of the monitoring undertaken to-date is summarised in Table 4 below. A complete set of results will be reported on completion of the intended testing programme.

Table 4 - Summary of Recorded Gas Levels.

Borehole No.	Date	Oxygen (steady) %	Carbon Dioxide (steady) %	Methane (steady) %	Flow Rate (l/hr)	Depth to Water (m)	Atmospheric Pressure (mb)
BH01A	14.06.21	16.5	4.9	ND	ND	2.70	1003
	30.06.21	16.1	4.5	ND	ND	DRY	1003
	14.07.21	15.4	4.4	ND	ND	DRY	1005
BH03	14.06.21	18.3	1.5	ND	ND	3.30	1003
	30.06.21	19.5	1.7	ND	ND	3.60	1004
	14.07.21	17.9	2.1	ND	ND	3.60	1005
BH04A	14.06.21	18.2	1.4	ND	ND	1.90	1002
	30.06.21	19.8	1.3	ND	ND	2.10	1003
	14.07.21	17.7	2.3	ND	ND	2.20	1005
BH06E	14.06.21	12.9	4.9	ND	ND	DRY	1001
	30.06.21	16.3	4.3	ND	ND	DRY	1002
	14.07.21	14.8	4.6	ND	ND	DRY	1004
BH08A	14.06.21	18.0	1.2	ND	ND	DRY	1001
	30.06.21	20.0	0.9	ND	ND	DRY	1002
	14.07.21	18.3	1.8	ND	ND	DRY	1004
BH11A	14.06.21	18.6	1.5	ND	ND	DRY	1001
	30.06.21	19.0	2.9	ND	ND	DRY	1001
	14.07.21	18.7	2.4	ND	ND	DRY	1003

8.3.4 A maximum steady carbon dioxide concentration of 4.9% was recorded in BH01A and BH06E. No steady methane has been recorded. No steady flow rates were detected in the monitoring stations.

8.3.5 Borehole 4A recorded initial peak levels of Methane of 1.4% which rapidly dropped down to zero on both occasions. Similarly, low initial flow rates of up to 4.4 l/hr have been recorded on two occasions which rapidly dropped to zero.

8.3.6 Due to the low levels of carbon dioxide on site, we would recommend the gas regime on this site be currently classified as **Green** by the NHBC traffic light system, or **CS1** by BS 8485:2015 Table 2.

8.3.7 The gas monitoring is ongoing and a final report confirming any gas protection measures required will be prepared when the monitoring is completed.

9.0 CONTAMINATION

9.1 HUMAN HEALTH RISK ASSESSMENT

9.1.1 The appraisal of contaminated land within the UK is based on a risk assessment approach. The method involves the principle of defining a source ► pathway ►receptor, linkage to establish a human health risk. For any risk to exist to a potential receptor from an identified contaminant there must be an unbroken source ► pathway ►target relationship.

9.1.2 In the first instance site data for the contaminant levels are compared against guidance such as the CLEA values published by DEFRA. Should the site values exceed the guidance criteria, the contamination levels are recognised to have the potential to pose a risk to human health. Two scenarios are then available: -

a) To break or remove one of the source ► pathway ►receptor linkages, by specifying an appropriate level of remedial work. Examples of remedial action may include the removal of the contaminated material or alternatively specifying a sufficient capping layer.

b) The alternative approach is to provide a more detailed human health site specific risk assessment. This will involve examining factors such as soil properties, exposure assumptions, groundwater flows and contamination composition.

9.2 CONTAMINATION RESULTS

9.2.1 As stated above, in order to put the analytical results into context, the data has in the first instance been assessed in relation to several sets of guidelines: -

9.2.2 The analytical results have been assessed via an initial screening assessment with regard to the current Contaminated Land Exposure Assessment model (CLEA UK) for human health, which has been produced for the Environment Agency and the Department of Environment, Food and Rural Affairs (DEFRA). The CLEA model provides Soil Guideline Values (SGVs) for a limited range of contaminants only, and these are based on risk to human health. As such they do not take into account potential risks to other receptors e.g. groundwater and third party land.

9.2.3 It is proposed to redevelop the site for residential properties with private garden areas. Soil results have therefore been assessed against the CLEA SGV's for residential use with plant uptake, as these are considered to be the most suitable guidelines to protect the most critical targets from contaminants via all possible exposure routes.

9.2.4 Where no CLEA SGV has been published, Generic Assessment Criteria (GAC) based on guidelines from the Chartered Institute of Environmental Health (CIEH) and Land Quality Management Ltd (LQM) S4UL document residential land use with plant uptake has been used. Where there is no GAC, guidance limits have been adopted from sources referenced in the table below.

9.2.5 A new approach has now been adopted for the calculation of SGV based on an acceptably low level of risk. These Category 4 Screening Levels (C4SL) have been calculated for six substances to date by modifying the toxicological/exposure parameters within CLEA. C4SLs have been used as tier 1 trigger levels within this assessment, superseding the previous CIEH and LQM SGVs.

9.2.6 Assessment of risk is considered as a tiered approach. Assessment based on non intrusive means is considered Tier 1 assessment, comparison against SGVs and GACs is a Tier 2 assessment, and the generation of and comparison with Site Specific Assessment Criteria (SSAC) is a Tier 3 assessment and is conducted where deemed appropriate following the Tier 2 assessment.

9.2.7 The sulphate and acid concentrations have been compared against the BRE digest "Concrete in Aggressive Ground" parts 1-4. This will enable the concrete class to be specified in relation to possible contact with aggressive soils.

9.2.8 The results of the chemical analysis are presented on the laboratory analysis sheets with Appendix C. A summary of the significance of the results is presented in Table 5.

Table 5

Comparison of contaminant against accepted guidance values for residential use with plant uptake

CONTAMINANT	SGV MG/KG	CONCENTRATION IN ALL SOILS. MG/KG	No. OF SAMPLES EXCEEDING GUIDANCE VALUES	PERCENTAGE OF SAMPLES EXCEEDING GUIDELINE VALUE
Arsenic	37 (4)	5.8-15	0/11	
Cadmium	22 (4)	<0.1-0.2	0/11	
Chromium (Total)	130 (2)	16-21	0/11	
Lead	200 (4)	19-45	0/11	
Mercury (Total)	1.2 (1)	<0.05-0.06	0/11	
Selenium	250 (1)	<0.5-2.0	0/11	
Copper	2400 (1)	21-36	0/11	
Nickel	180 (1)	15-33	0/11	
Zinc	3700 (1)	61-93	0/11	
Sulphate	0.24 (3)	0.03-0.07	0/11	
Thiocyanate	50	0.6-2.4	0/11	
Sulphide	250	<10-100	0/11	
Naphthalene	2.3 (1)	<0.1	0/11	
Benzo(a)pyrene	5 (4)	<0.1	0/11	
Dibenzo(a,h)anthracene	0.24	<0.1	0/11	
PAH (Total)	40	<1.6	0/11	
Phenols	760 (1)	<0.3	0/11	
Asbestos	No fibres	None	0/11	
pH	6-8	5.4-7.0	3/11	27.3%

(2) DEFRA CLR SGV's withdrawn used for initial comparison

(3) BS 8110 1985 Table 6.1

(4) Category 4 Screening Levels

9.2.9 No elevated levels of heavy or phytotoxic metals were recorded in the samples from site.

9.2.10 There were no elevated levels of PAH (Total) or individual PAH compounds.

9.2.11 No asbestos was detected in the samples taken from site.

9.2.12 No elevated sulphate levels were recorded in the samples taken from site, however, three samples proved pH values of less than 6. This corresponds to a design sulphate class DS-1, ACEC class AC-3z, when compared against the BRE Special Digest 1 "Concrete in aggressive ground".

9.3 QUALITATIVE RISK ASSESSMENT

9.3.1 The Qualitative Risk Assessment is based upon the previously discussed source ► pathway ►receptor principle. In relation to the proposed site these may be described as follows:-

9.3.2 **SOURCE**

i) No contaminants identified in the samples taken from site.

ii) No elevated levels of ground gas.

9.3.3 **PATHWAYS**

i) Ingestion of contamination material.

ii) Inhalation of contaminated particles.

iii) Dermal contact with the known contamination.

iv) Leaching to controlled waters.

9.3.4 **RECEPTORS**

i) Residential site users.

ii) Construction and maintenance workers.

iii) Controlled waters.

iv) The building structure.

9.3.5 Each of the receptors will now be appraised and attribute the likely risks involved.

i) Residential site users.

Based on the chemical results obtained it is considered that there is currently a **negligible** risk to end users from localised ground contamination on-site.

No elevated levels of heavy or phytotoxic metals were detected in the samples taken from site.

No elevated PAH compounds were detected in the samples taken from site.

No asbestos was detected in the samples taken from site.

The chemical analysis undertaken on the samples of topsoil have proved it suitable for re-use on site. Prior to construction work commencing on site, it is recommended that the existing topsoil is scraped and stockpiled behind protective fencing to prevent cross contamination during the demolition and construction work.

Due to the low level of carbon dioxide recorded on site, we would recommend the gas regime on this site be currently classified as **Green** by the NHBC traffic light system, or **CS1** by BS 8485:2015 Table 2.

The gas monitoring is ongoing and a final report confirming any gas protection measures required will be prepared when the monitoring is completed.

ii) Construction and Maintenance Workers.

It is considered that there is a **low** risk to construction and maintenance workers from the redevelopment of the site. However, it is recommended that contractors are made aware of the low concentrations of asbestos present within the made ground.

Construction workers should always wear PPE including overalls, boots and gloves when handling the contaminated materials onsite. In addition eating, drinking and smoking should be restricted to designated areas where the above hygiene facilities are available.

iii) Controlled Waters

The samples taken from site proved clean from contamination. It is therefore considered unlikely that there is a risk to groundwater and controlled waters from existing contamination on site.

However, due to the presence of the watercourses on the western boundary of the development site, a temporary works plan should be prepared to ensure no surface water run-off during development on site causes pollution to the watercourse.

iv) Building Structures.

Service providers should be forwarded the final validated chemical levels in order for them to provide an accurate specification for the apparatus to be provided. New services should be surrounded and backfilled with clean material to afford some

protection to the apparatus and allow any future maintenance work to be undertaken in clean material.

No elevated sulphate levels were recorded in the samples taken from site, however, three samples proved pH values of less than 6. This corresponds to a design sulphate class DS-1, ACEC class AC-3z, when compared against the BRE Special Digest 1 "Concrete in aggressive ground".

10.0 CONCLUSIONS AND RECOMMENDATIONS

10.1 GEOTECHNICAL ASSESSMENT

10.1.1 The fieldwork generally proved clays or fill material overlying a mudstone bedrock, with shallow seams of coal encountered within the mudstone. For initial design purposes we would envisage a safe bearing capacity of 100kN/m2 where foundations are cited onto the firm clay strata and 150kN/m2 where foundations are extended onto the weathered mudstone strata.

10.1.2 We would therefore initially suggest that the site is divided into two separate areas. Within the former opencast mine in the north of the site, piled foundations will be required due to the depth of fill encountered. For the remainder of the site, strip/trench fill footings may be adopted.

10.1.3 WITHIN THE FORMER OPENCAST MINE IN THE NORTH

10.1.3.1 The ground investigation proved up to 8m of colliery spoil and re-engineered clays in the north of the site. The approximate extent of the open cast site has been indicated on the site investigation plan in Appendix A.

10.1.3.2 The re-engineered clays and colliery spoil are not considered a suitable foundation material and therefore all loadings should be taken through these materials onto suitable underlying strata.

10.1.3.3 We would therefore suggest that the proposed two storey traditional house construction should be constructed on piled foundations with a reinforced concrete suspended ground beam in this area of the site. The following general comments relating to piling are provided for guidance, and further advice should be sought from a specialist-piling contractor.

10.1.3.4 Piled foundations should extend and be socketed into the underlying bedrock. Pile records should be checked to ensure a minimum 3m pile length and that similar pile lengths are achieved throughout a plot and between adjacent structures.

10.1.3.5 The safe working load that may be supported on a pile is dependent on the pile diameter, its founding depth and the method of installation. As piles would be

founded in bedrock, they will be essentially end bearing, although there may also be some shaft adhesion within the infilled materials. It is essential that pile design allows for negative skin friction.

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

10.1.3.7 Driven piles may lessen the volume of potentially contaminated fill material requiring off-site disposal, compared with continuous flight auger piled foundations. However, driving can induce some ground vibration. Assessment of any vibration risk to adjacent structures and/or existing site features should be undertaken by pile designer.

10.1.3.8 On completion of the piling works, pile testing should be undertaken to confirm the adequacy and load carrying capacity of the installed piles.

10.1.3.9 Should any shallow obstructions occur, i.e. large boulders, they should either be grubbed-up, or alternatively replacement piles installed. The pile logs should be checked prior to the piling rig departing site, to ensure consistent pile lengths are installed throughout the site.

10.1.3.10 The new houses can be built off ring beams designed to span the piles. In order to bond them to the piles, the tops of the piles must be tied to the reinforcement within the ground beams. This can be achieved by a variety of methods dependent upon the type of piles adopted.

10.1.3.11 For piled foundations suspended floor slabs should be utilised. A pre-cast 'Beam and Block' concrete ground floor construction could be utilised, and suspended across the ring beams.

10.1.3.12 In some circumstances pile foundations can provide a pathway for the vertical migration of contamination. The pile design should be undertaken in accordance with the Environment Agency's guidance "Piling into Contaminated Sites".

10.1.4 REMAINDER OF THE SITE

10.1.4.1 Outside the former opencast mine, the proposed low rise residential constructions should be constructed on strip/trench fill footings founded entirely onto the clay strata. Where mudstone is encountered within the excavations, the foundations should be deepened to lie entirely onto the mudstone strata to avoid differential settlement. The foundation widths will vary dependent upon the line loadings calculated.

10.1.4.2 If the coal strata is encountered within the foundation excavation, the foundations should be extended to below the coal seam and the coal seam immediately sealed with blinding cement to prevent spontaneous combustion.

10.1.4.3 All foundations should be placed below a line of 45degrees drawn up from the base of any services or other structures.

10.1.4.4 Where existing foundations or structures are encountered during construction, these should be totally removed from the excavations to enable the new foundations to be constructed without obstructions.

10.1.4.5 The geological maps for the site indicate that there are two fault lines crossing the site. The faults are not thought to be active; however we would recommend that the strip foundation design is strengthened in areas affected by the fault lines to accommodate any slight differential settlement. This would usually involve doubly reinforcing the foundation within a deeper section of concrete.

10.1.5 At present it is not anticipated that excessive ground water control measures will be required. Please note that ground water flows can vary throughout the year and a further assessment should be undertaken if construction work is proposed following a prolonged rainfall event.

10.1.6 Wherever any foundations are located near existing or proposed new trees, their foundations must be sited below the root growth zone. Reference should be made to the NHBC standards Chapter 4.2 "Building Near Trees" which provides guidance on foundation criteria, depths and construction. All services should be similarly protected. Plasticity testing of the clays on site has shown them to be of low volume change potential.

10.1.7 No elevated sulphate levels were recorded in the samples taken from site, however, three samples proved pH values of less than 6. This corresponds to a design sulphate class DS-1, ACEC class AC-3z, when compared against the BRE Special Digest 1 "Concrete in aggressive ground".

10.2 MINING

10.2.1 The Coal Authority Report states that the property is in a surface area that could be affected by underground mining in 10 seams of coal at 40m to 490m depth, and last worked in 1987. In addition to this, the Coal Authority report states that the property is in an area where the Coal Authority believes that there is coal at or close to the surface. Historically, shallow and surface coal has been worked by private individuals and these workings have been unrecorded by the Coal Authority.

10.2.2 The property is also within the boundary of an opencast site from which coal has been removed by opencast methods. The Coal Authority Interactive Map Viewer indicates the open cast mining to have occupied approximately the northern half of the site.

10.2.3 Overall, the boreholes undertaken indicate three coal seams passing beneath the site. The upper coal seam is 0.9-1.0m thick and outcrops halfway through the site as indicated on the Coal Authority Plans. This has been worked via opencast methods in the north of the site.

10.2.4 A second coal seam has been encountered, within the deeper boreholes, beneath the opencast workings at depths of 12.8-17.2m beneath existing ground levels, and at depths of 3.3-8.5m to the south of the opencast workings. This coal seam was also 0.9-1.0m thick.

10.2.5 A third coal seam was encountered with BH02 in the south of the site. This was the only deep borehole to 30m undertaken at the lower end of the site and proved a 0.4m thick coal seam at 21.3-21.7m below existing ground levels. This would dip northwards below the depth of the remaining deep boreholes undertaken.

10.2.6 Except the opencast workings associated with the uppermost coal seam in the north of the site, none of the coal seams encountered showed evidence of being extracted.

We would therefore consider there to be a low risk to the future development of the site from the shallow coal seams encountered beneath the site.

10.3 GROUND FLOOR SLAB – GAS MEASURES

10.3.1 As discussed previously, gas monitoring stations were installed in six of the borehole locations on site due to the possibility of ground gas migration from infill material to the former opencast workings on site.

10.3.2 A maximum steady carbon dioxide concentration of 4.9% was recorded in BH01A. No steady methane concentrations have been recorded. No steady flow rates have been detected on site.

10.3.3 The proposed development consists of low rise residential housing and therefore the gas regime has been characterised in accordance with the traffic light methodology as outlined in CIRIA Report C665. Due to the low carbon dioxide levels on site, we would recommend the gas regime on this site be currently classified as **Green** by the NHBC traffic light system, or **CS1** by BS 8485:2015 Table 2.

10.3.4 No Radon Protection measures are required for the site.

10.3.5 Due to depth of fill on site exceeding 600mm, a ventilated sub-floor void will be required in accordance with NHBC Chapter 5.2.

10.3.6 A detailed analysis of the results and any gas protection measures required will be confirmed on completion of the on-site gas testing in a separate report.

10.4 CONTAMINATION ASSESSMENT

10.4.1 No elevated levels of heavy or phytotoxic metals were detected in the samples taken from site.

10.4.2 No elevated PAH compounds were detected in the samples taken from site.

10.4.3 No asbestos was detected in the samples taken from site.

10.4.4 The chemical analysis undertaken on the samples of topsoil have proved it suitable for re-use on site. Prior to construction works commencing on site, it is recommended

that the existing topsoil is scraped and stockpiled behind protective fencing to prevent cross contamination during the construction work.

10.4.5 Should any suspected areas of contamination be exposed during site strip/construction, an engineer should be contacted to determine if additional chemical testing should be undertaken. The on-site staff should maintain a photographic record and dates of any exposed contaminated material.

10.5 HIGHWAYS

10.5.1 Based on a visual inspection of the fill materials on site we would recommend that CBR testing should be undertaken at road formation level. As an approximate guide the tests should be undertaken at 25m centres along the proposed road centre line. If a minimum 2% CBR is not achieved the following options are available, dependent upon the results achieved:-

i) The existing strata to be excavated an additional depth to allow the appropriate road capping construction to be incorporated. The capping material should comply with Series 600 Specification for Highway Works 2009. The selected material should be tested for compliance prior to backfilling commencing.

ii) The overall depth of capping construction could be reduced via the inclusion of a geogrid reinforcement layer at road formation level. This would need to be agreed with Barnsley MBC Highways prior to use on site.

iii) Where the highway crosses high wall features, geogrid reinforcement is likely to be required to reduce the risk of differential settlement. This will need to be agreed with Barnsley MBC Highways.

10.6 SURFACE WATER DRAINAGE

10.6.1 Only TP01, of the two soakaways, recorded a small drop in water level during the five hour infiltration tests. In TP02 the water level remained stationary during the test.

10.6.2 We would therefore not consider infiltration methods a suitable long term drainage solution for the development.

10.6.3 A discharge rate and point of connection to the existing watercourse in the south west of the site will need to be agreed with Barnsley MBC Lead Local Flood Authority.

11.0 SUGGESTED FURTHER WORK

11.1 Gas monitoring to be completed and final assessment on gas protection measures to be made.

12.0 APPROVALS

12.1 Proposals for the remediation of contaminated land may require the approval of numerous bodies.

These include:

a) Barnsley MBC Environmental Health Department as required by the building and planning regulations.

b) The NHBC or similar as they will provide the insurance costs to cover the property.

c) The Environment Agency if there are risks of contamination to ground or surface water systems. They will also require notification if material is removed from site and taken to an appropriate tip.

d) Relevant highways and drainage authorities and other service companies may also wish to know about the level of contaminants.

Prepared by

M.Dean. BSc (Hons) HND

Checked by

M. Huddleston. MEng

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