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167 Heckmondwike Road

Phase II Interpretative Report

May 2017

Document Control

Project:	167 Heckmondwike Road
Client:	Lydian Developments Ltd
Job Number:	RBG016

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Issue	Date	Status
002	June 2017	Final

Contents Page

APPENDIX CONTENTS

DISCLAIMER

This report was produced by RB Geotechnical for Lydian Developments Ltd for the specific purposes of a Phase II Intrusive Investigation and Interpretative Report, for the land at 167 Heckmondwike Road, Dewsbury. This report may not be used by anyone else other than Lydian Developments Ltd without their express permission. In any event, RB Geotechnical accepts no liability for any costs, liabilities or losses arising from the use of reliance upon the contents of this report by anyone other than Lydian Developments Ltd.

1.0 INTRODUCTION

1.1 Brief and Scope

RB Geotechnical was commissioned by Mr David Bradley of Lydian Developments Ltd, to carry out a Phase II Intrusive Site Investigation on land at 167 Heckmondwike Road, in West Yorkshire. The site at 167 Heckmondwike Road is intended for the construction of ten residential properties with private back gardens and a new access road.

RB Geotechnical undertook an intrusive ground investigation on 27th March 2017 and 28th March and an additional investigation on 30th May, in order to gain the necessary information required to make an assessment of the underlying ground conditions. This assessment was designed to assess both the underlying coal seams for potential workings, the geotechnical nature of the site and for potential ground contamination.

This report discusses the findings of this ground investigation and provides an analysis which includes a series of conclusions and recommendations relating to the potential risks and constraints of the proposed development.

1.2 Terms and Conditions

This report has been prepared for Lydian Development Ltd in support of a planning application (planning application number 2017/90555) relating to the proposed development of ten residential properties with private back gardens and driveways. The environmental information in this report has been summarised following a review of the Phase I assessment carried out by RB Geotechnical (Reference: Land at 167 Heckmondwike Road, Dewsbury, WF13 3NS, Phase I Desk Study Report, January 2017).

1.3 Scope and Objectives of Report

The purpose of this report is to provide factual and interpretative information required to comply with the requirements of a Phase II Intrusive Site Investigation and assessment of coal mining legacy and land contamination as required by the planning regime. The scope of the report is as follows:

- To provide general information on the site such as location and description;

- To summarise the environmental and historical setting of the site; e.g. landfills, permits, sensitive land uses and historical land uses;
- To summarise the ground investigation and its findings;
- Provide factual information and descriptions of ground conditions;
- To make preliminary geotechnical recommendations;
- To assess coal mining legacy of the site;
- To provide a quantitative risk assessment for the proposed end use of the site; and
- To provide recommendations for further works where necessary.

1.4 Constraints and Limitations

This report is intended for Lydian Developments Ltd for the purpose of assisting them in assessing the site for possible coal mine workings, geotechnical risk and for possible ground contamination.

RB Geotechnical has endeavoured to assess all information provided to them. The report includes summaries of information from external sources and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon. The preliminary geotechnical design options and recommendations summarised in this report relate to the feasibility of developing on the site and are based on information available at the time of writing the report. Any substantial changes to the intended use of the site may require a reassessment of the implications of the risks identified and a review of the geotechnical design options.

The conclusions resulting from this study are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

It should be noted that although every effort has been made to ensure the accuracy of the data obtained from the investigation, the possibility exists for variations in ground and groundwater conditions between and around the borehole locations. In addition, groundwater levels will vary seasonally and with changes in weather conditions.

1.5 Sources of information

The existing environmental and historical information within this report has been obtained following a review of the Phase I Desk Study carried out by RB Geotechnical, which includes a Groundsure Report and Historical OS Maps.

The initial coal mining information has been obtained following a review of the Coal Mining Risk Assessment carried out by RB Geotechnical, which included a Coal Mining Report and a Consultants Coal Mining Report.

Geotechnical and Environmental information has been obtained following a review of the geotechnical and contaminated land laboratory test results, along with the findings of the intrusive ground investigation.

The sources of information used for this report are:

- RB Geotechnical, Land at 167 Heckmondwike Road, Dewsbury, WF13 3NS, Phase I Desk Study Report, January 2017, RBG011
- RB Geotechnical, Land at 167 Heckmondwike Road, Dewsbury, WF13 3NS, Coal Mining Risk Assessment, March 2017, RBG013
- RB Geotechnical Land at 167 Heckmondwike Road, Exploratory Hole Logs, June 2017
- I2 Laboratory, April 2017 Report No. 17-44465-1, Report No. 17-44649, and Report No. 17-45089-1

Although every effort has been made to ensure the accuracy of the information contained herein, no checks have been carried out to ensure the accuracy of information obtained from third parties and no liability can be accepted for any errors or misinterpretation of the third party information where it has been incorporated into this report.

2.0 SITE DETAILS

2.1 Site Location and Description

The site is situated approximately 2000m to the North West of Dewsbury town centre in West Yorkshire, at a 0.17ha size plot of roughly trapezoidal land by 167 Heckmondwike Road, WF13 3NZ. The National Grid Reference for the centre of the site is 422675, 422101.

The site is currently occupied by areas of overgrown weeds and bushes, along with sections of tarmac and concrete hardstanding, with sections of old brick walls and floor slabs towards the South East corner of the site (in the place of the building which once stood). A number of trees also exist across the site.

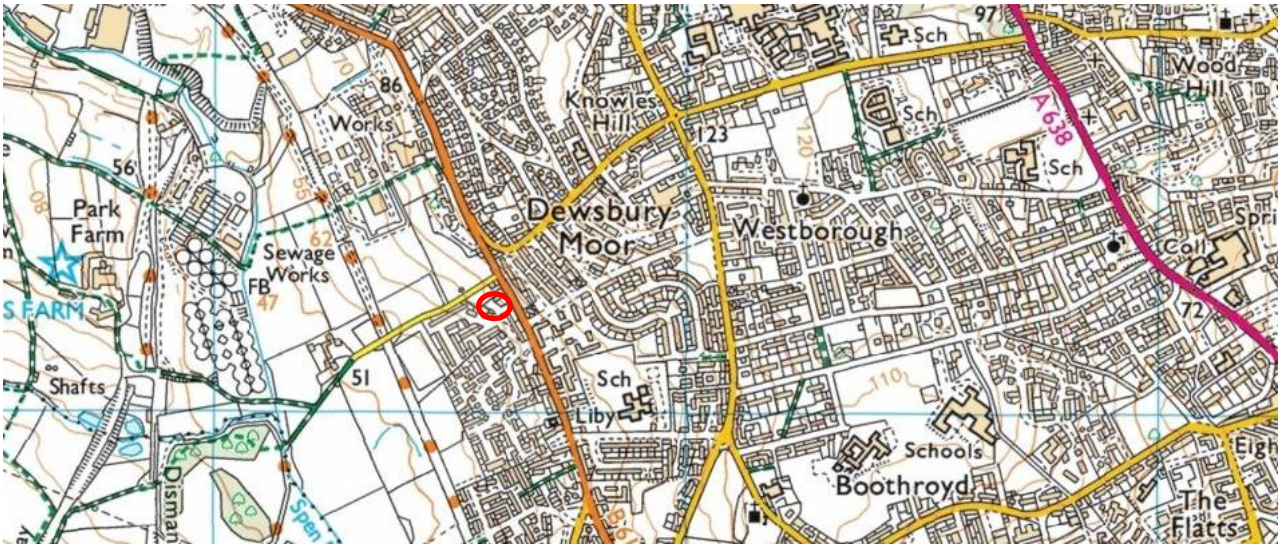
The Northern site boundary is marked by Spen View, Eastern site boundary by Heckmondwike Road and the Western site boundary by the back gardens of existing residential properties. The Southern site boundary is marked only by herras fencing, separating the site from another area of tarmac and old terraced car garages.

Topographically the site is at a lower elevation than Heckmondwike Road, and slopes down from the West towards the East, with an area of raised land situated in the North West corner.

Access to the site is off Spen View to the North.

The immediate surrounding area consists of mainly residential streets and houses. The approximate site location is shown by the red circle in Figure 2.1.

Figure 2.1 Site Location (Bing Maps)



2.2 Proposed Development

The proposed development comprises ten residential properties (one row of four terraced and one row of six), each with private back gardens and driveways. Additionally a new access road is proposed off Spen View to the North. The proposed development (and exploratory hole location) plan is presented as Appendix A.

3.0 EXISTING INFORMATION

3.1 General Site History

Historical maps show the Woolpack Inn to have been on the site since at least 1852, whereby during the years that followed, small scale demolition of out buildings took place, up until the present day, when the whole pub building was recently demolished.

The surrounding area has undergone largely residential development through the years. Collieries and other industrial uses have been mapped within 1000m of the site through the years, but have since become disused or ceased working.

3.2 Geology, Hydrology and Hydrogeology

3.2.1 Geology

According to the published geological maps and information on the BGS GeoIndex website, no superficial deposits are mapped for the site. Geological maps do however indicate that the site is underlain Interbedded Mudstone, Siltstone and Sandstone of the Pennine Lower Coal Measures.

No faults are mapped on the site itself, however a fault is mapped 53m to the North East of the site, running North to South.

3.2.2 Hydrology

No surface water features exist on site, nor with 250m of the site. The EnviroInsight Report indicates that a land drain is situated 277m to the South West of the site (This is the nearest water feature). The River Spen is situated approximately 600m to the West of the site. There are no Source Protection Zones within 500m of the site boundary.

3.2.3 Hydrogeology

The underlying Mudstone/Sandstone and Siltstone of the Pennine Lower Coal Measures is classified as a Secondary A Aquifer, with a High Urban Leaching Potential. No records of discharge consents exist within 500m of the site, and there are no pollution incidents to controlled waters recorded within 500m of the site.

3.3 Environmental Considerations

3.3.1 Landfill Sites

There are two recorded active landfill sites within 1000m of the site, situated 259m to the South West and 846m to the South West. Five historic landfill sites are noted within 1000m of the site, situated 373m to the South West, 769m to the West, 771m to the South West, 797m to the South and 908m to the North West.

3.3.2 Potentially Infilled Land

There are records of 73 potentially infilled land features within 500m of the site. These potentially infilled land features include an unspecified pit (situated 36m to the South East dated 1892), Unspecified Ground Workings situated 129m to the North East, Reservoirs and Ponds situated from 176m to 194m to the South, Collieries, Unspecified Heaps, Refuse Heaps, Pits, Sewage Works, Cuttings and other Ground Workings.

3.3.3 Potentially Contaminative Land Uses

A total of 113 potentially contaminative historic land uses have been mapped within 500m of the site boundary. These comprise unspecified pits, mills, collieries, sewage works, engineering works, chemical works and other works buildings. The nearest current potential contaminative land uses are the vehicle hire service situated 86m to the South, the MOT garage situated 199m to the South and an electricity sub-station situated 249m to the South East.

3.4 Preliminary Contamination Assessment

The only potential sources of on-site contamination identified were from Made Ground where building construction and demolition has taken place over the years, and potential contaminants around the car parking areas due to fuel leakages.

The surrounding area initially consisted of open grassland to the West and North, with a scattering of collieries. Over the years the surrounding area has undergone extensive residential and in some areas industrial development. What was noted however is the number of areas of potential infilled land situated within a 250m radius of the site, which may have the potential to pose off-site sources of ground gas. The

only real other form of potential off-site contamination identified was from the MOT garage situated 200m to the South of the site.

Therefore the site was identified as having an overall Moderate/Low risk of potential pollutant linkage.

It was therefore recommended that an intrusive investigation be carried out to assess the potential for contamination within the shallow soils (namely around the current car parking areas and areas where demolition has or is to take place). This investigation should also include the installation of ground gas monitoring standpipe, to assess the risk of gas vapours migrating to the site from any infilled land.

3.5 Coal Mining Risk Assessment

The Coal Authority Coal Mining Report states that the site is in an area that could be affected by underground mining in three seams of coal. The Consultants Coal Mining Report, has identified these seams as the Silkstone (known as Middleton Main in West Yorkshire) Coal Seam at a depth of 18.0mbgl, with an extraction thickness of 0.45m, the Black Bed Coal Seam at a depth of 176m below ground level, with an extraction thickness of up to 0.76m, and the Better Bed Coal Seam, encountered at a depth of 218mbgl, with an extraction thickness of 0.69m. These seams were noted as last being worked in 1878, 1905 and 1900 respectively. The Coal Authority believes that any movement in the ground due to this coal mining activity should have stopped.

The Coal Authority Report states that there are no mine entries within 20m of the site boundary.

It was therefore recommended that rotary open hole boreholes be carried out across the site, to depths of at least 20.0mbgl. These will enable a sufficient assessment of the shallowest coal seam (if encountered) beneath the site, to ensure that there is no evidence of mine workings and that sufficient rock coverage exists.

4.0 INTRUSIVE INVESTIGATION

4.1 Design

The Ground Investigation was designed by RB Geotechnical to investigate the ground conditions and groundwater conditions of the site. The scope of the investigation was determined based on the findings of the Phase I Contaminated Land Desk Study and the Coal Mining Risk Assessment.

4.2 Ground Investigation Activities

The Ground Investigation was undertaken in general accordance with:

- BS 5930 (1999). Code of Practice for Ground Investigation;
- BS1377. Methods of test for Soils for Civil Engineering Purposes; and
- BS 10175:2011 (2011). Investigation of Potentially Contaminated Sites – Code of Practice.

The Ground Investigation comprised the following:

- Four Rotary Open Hole Boreholes to depths of 25.0mbgl, to assess the condition of the underlying coal seams;
- Installation of gas and groundwater monitoring standpipe into three Rotary Open Hole Boreholes;
- Ten Machine Excavated Trial pits to depths of 1.00mbgl and 2.20mbgl, to assess shallow ground conditions and obtain samples for geotechnical and contamination laboratory testing; and
- Six Gas Monitoring visits following the Ground Investigation to assess the groundwater and ground gas regime on site.

This Ground Investigation was undertaken over a period of two days from 27th March 2017 and 28th March 2017. The exploratory holes were logged and sampled by a qualified RB Geotechnical engineer.

An exploratory hole location plan is shown in Appendix A.

4.3 Sampling and In-Situ Testing

Small disturbed samples were recovered from the Trial Pits and stored in plastic pots and jars placed into a cool box. No in-situ testing was carried out during the investigation.

4.4 Laboratory Testing – Geotechnical

All Geotechnical laboratory testing was scheduled by RB Geotechnical, and was intended to provide information on the geotechnical properties of the underlying soils, mainly in the areas of proposed building footprints. Geotechnical Laboratory Testing was carried out to BS1377:1990 Methods of Test for Soils for Civil Engineering Purposes. Testing was carried out by i2 Analytical Ltd of Watford, which is registered as UKAS Testing laboratory No. 4041. Table 4.1 summaries the Geotechnical Laboratory Testing that was carried out. All Geotechnical Laboratory results are shown in Appendix C

Table 4.1 Summary of Geotechnical Laboratory Testing

Analysis	Total number of Samples
Atterberg Limits	6
Moisture Content	6
pH	6
Water Soluble Sulphates	6

4.5 Laboratory Testing – Environmental

All chemical (contamination) laboratory testing was scheduled by RB Geotechnical and was intended to provide contamination data for the specific areas sampled. The scope of the testing was designed to enable comments regarding characterisation of potential contamination on site.

A total of six soil samples were sent to i2 Analytical Ltd of Watford, which is registered as UKAS Testing laboratory No. 4041. Table 4.2 summaries the Laboratory Testing carried out. Full chemical laboratory testing results are shown in Appendix D.

Table 4.2 Summary of Chemical Laboratory Testing

Analysis	Total number of Samples
Heavy Metals	9
Cyanide	9
Sulphate	9
SOM	9
pH	9
Speciated PAH	9
Total TPH	9
phenol	9
Asbestos ID	9
WAC Testing	2

4.6 Groundwater and Ground Gas Monitoring Standpipe

Gas and groundwater monitoring standpipes were installed into three Rotary Open Hole boreholes (RO1, RO2 and RO4). Installation details are as follows:

- RO1: 2.0m of plain standpipe and 1.50m of slotted screen standpipe. Standpipe installed to assess potential ground gases within shallow coal seam;
- RO2: 5.0m of plain standpipe and 1.0m of slotted screen standpipe. Standpipe installed to assess potential ground gases within shallow coal seam;
- RO4: 0.50m of plain standpipe and 1.50m of slotted screen standpipe. Standpipe installed to assess potential ground gases within shallow Made Ground material.

In-situ gas monitoring was carried out in each of these Rotary Open Hole Boreholes, using a portable gas meter which measures Oxygen, Methane, Carbon Dioxide and air pressure.

5.0 INTRUSIVE INVESTIGATION FINDINGS

5.1 Ground Conditions Encountered and Geotechnical Laboratory Results

Full exploratory hole logs are presented in Appendix B, with the exploratory hole location plan presented in Appendix A. Below is a detailed summary of the ground conditions encountered during the investigation.

5.1.1 Tarmac Hardstanding

All exploratory holes except RO1, TP01, TP05 and TP06 were carried out in areas of a black Tarmac hardstanding, with an average thickness of 0.10m.

5.1.2 Topsoil

A dark brown silty clay Topsoil was encountered in exploratory holes RO1 (in the South West corner of the site), TP05 and TP06 (both in North of the site), all of which are in areas of soft landscaping. This TOPSOIL contains fine fragments of brick, ash and glass and has an average thickness of 0.35m.

5.1.3 Sub-Base

A grey, brown limestone gravel Sub-Base was encountered beneath the Tarmac in all exploratory holes except RO1, TP05 and TP06 (which were undertaken in areas of soft landscaping) and TP01, TP07 and TP08, which were undertaken in an area of raised ground in the South East corner of the site. This Sub-Base had an average thickness of 0.30m.

5.1.4 Made Ground

Made Ground was encountered in all exploratory holes except RO2 and TP04 (Not including Sub-Base), as a dark brown, black, grey sandy gravelly clay, with gravel of fine to coarse concrete, brick, ash, clinker, sandstone and mudstone.

Made Ground was encountered at depths from 0.10mbgl to 0.60mbgl, with an average thickness of 0.80m.

In TP01 (which was undertaken on an area of raised land approximately 1.00m higher than the rest of the site), this Made Ground contained a layer of intact concrete slab at the surface with a thickness of 0.10m, then underlain by the same Made Ground material encountered across the rest of the site. Exploratory

holes TP07 and TP08 were also undertaken on this raised area (closer to Heckmondwike Road), which was approximately 1.50m higher than the rest of the site. Made Ground was encountered immediately beneath the thin Tarmac layer, and comprised a similar material to the Made Ground encountered across the rest of the site, in addition to clear evidence of old building foundations.

5.1.5 Highly Weathered Bedrock - Cohesive

A highly weathered bedrock of a mixed silty gravelly CLAY, with gravel of fine to coarse sandstone and/or mudstone, was encountered in all exploratory holes except RO3, RO4 and TP04. This stratum was encountered at an average depth of 0.80mbgl, with an average thickness of 0.65m.

Atterberg Limit testing was carried out on four samples of this stratum at depths ranging from 0.80mbgl to 1.50mbgl. Measured Moisture Contents ranged from 19% to 33%, Liquid Limits ranged from 35% to 52%, Plastic Limits from 20% to 27% and Plasticity Indices from 15% to 28%. These results indicate a clay material of Intermediate to High Plasticity, with a Low to Medium Volume Change Potential (After NHBC 2008, Chapter 4, Building Near Trees).

The Atterberg Limit results generally show a trend of becoming less plastic with depth.

5.1.6 Highly Weathered Bedrock – Granular

In exploratory holes RO3, RO4, TP04, TP09 and TP10 (situated around the centre to North East of the site) and TP08 (in the South East corner of the site) a largely granular weathered bedrock was encountered as a brown clayey GRAVEL of fine to coarse mudstone and/or sandstone. This stratum was encountered at depths ranging from 0.40mbgl (in TP04 and TP09) to 2.0mbgl (in RO4).

One Atterberg Limit test was carried out on a sample of this material, with a measured Moisture Content of 15%, Liquid Limit of 30%, Plastic Limit of 19% and Plasticity Index of 11%. These results classify the clay parts of this stratum as being of a Low Plasticity, with a Low Volume Change Potential.

5.1.7 Bedrock - Mudstone/Sandstone

Intact bedrock of the Pennine Lower Coal Measures was encountered in all four Rotary Open Hole boreholes as a mix of layers of Mudstone and Sandstone, interbedded with coal seams. The intact bedrock was encountered at depths ranging from 1.30mbgl in RO2 (situated in East of the site), to 2.0mbgl in RO4

(situated in North East corner of the site). Initially the bedrock was encountered in a weathered condition, but becomes more intact with depth.

5.1.8 Coal Seams

Coal seams were encountered in all four Rotary Open Hole boreholes and one machine excavated Trial Pit TP02.

The shallow coal seam was encountered in Rotary Open Hole RO1 at 1.80mbgl with a thickness of 1.80m, and in TP02 at 1.50mbgl (base of stratum not encountered). This shallow coal seam was encountered as a highly weathered largely soft clayey/gravelly material, with occasional fine to coarse coal gravel, which became less clayey with depth

Coal Seams were also encountered at greater depths in all four Rotary Open Hole Boreholes, with a summary of depth and thickness of coal seams encountered shown in Table 5.1.

Table 5.1 Summary of Coal Seams Encountered

Borehole ID		Borehole RO1	Borehole RO2	Borehole RO3	Borehole RO4
Final Depth (mbgl)		25.00	25.00	25.00	25.00
Depth to Rockhead (mbgl)		1.50	1.30	1.60	2.00
Shallowest Coal Seam Encountered	Depth (mbgl)	1.80	5.20	4.80	9.90
	Thickness (m)	1.80	2.10	0.70	0.30
Second Coal Seam Encountered	Depth (mbgl)	9.30	11.90	12.00	NOT ENCOUNTERED
	Thickness (m)	0.20	0.80	0.90	NOT ENCOUNTERED

Evidence of Mine Workings?	**NO**	**NO**	**NO**	**NO**
10 x Competent Cover (CIRIA 1989)*	**NO**	**NO**	**NO**	**NO**

Note *: CIRIA (Construction over abandoned mine workings, 1989), suggests a thickness of solid rock through which a void can migrate is 7h to 10h above the roof of the workings, where h is the height of the workings (generally assumed to be similar to the seam thickness). The lower end of this range (7h) is generally only applicable where the overlying strata are predominantly thickly bedded sandstones, which are not typical of this site. Therefore the 10h rule should be used.

During the drilling of these four Rotary Open Hole Boreholes, no sudden loss of water flush occurred indicating no presence of mine workings or voids in any of the coal seams identified. As no evidence of mine workings was encountered, it is therefore irrelevant that less than 10h was encountered in the coal seams.

One Atterberg Limit test was carried out on a sample of the shallow weathered coal seam encountered in TP02, with a measured Moisture Content of 27%, Liquid Limit of 61%, Plastic Limit of 27% and a Plasticity Index of 34%, classifying it as a stratum of High Plasticity, with a Medium Volume Change Potential.

5.2 Visual and Olfactory Observations of Potential Contamination

Made Ground was encountered in all exploratory holes, containing a mix of brick, concrete, limestone, sandstone, mudstone, ash, clinker and glass. Apart from these Made Ground materials within the shallow soils, there was no evidence or indication of any other form of contamination on the site.

5.3 Groundwater and Ground Gas

During the ground investigation, there was no evidence of ground gas or mine gases. Additionally there was no evidence of groundwater strikes (however it is difficult to accurately assess groundwater strikes during Rotary Open Hole Drilling due to the drilling methods used).

The risks associated with ground gases have been considered in accordance with British Standard BS 8485:2007 “Code of Practice for the Characterisation and Remediation from Ground Gas in Affected Developments”, CIRIA Report C665 “Assessing Risks Posed by Hazardous Gases to Buildings” and NHBC Report No.4 “ Guidance on Evaluation of Development Proposals on Sites where Methane and Carbon Dioxide are Present”.

Groundwater and Ground Gas Monitoring was carried out on six separate occasions following the intrusive Ground Investigation on the following dates: 4th April 2017, 12th April 2017, 18th April 2017, 24th April 2017, 3rd May 2017 and 9th May 2017.

Throughout the six gas monitoring visits, measured Methane levels were zero in all exploratory holes. Carbon Dioxide levels were also measured to be very low on all six occasions, with results ranging from 0.10% to 0.30%. Additionally no positive flow rates were measured during the monitoring.

Adopting the traffic light system of the NHBC Report No.4, the Gas Screening Values (GSV) for this site are calculated as being:

- Methane GSV = 0.00l/hr (litres/hour)
- Carbon Dioxide GSV = 0.00003l/hr (litres/hour)

On this basis using the NHBC traffic light system, the site can be given a gas risk classification of GREEN, whereby ground gas protection measures are not required.

Shallow groundwater monitoring was also carried out in conjunction with the gas monitoring. On all six monitoring visits, no groundwater was encountered in any of the monitoring standpipe. Seasonal variation in groundwater levels will occur and groundwater may be shallower during the winter months. Additionally, there is the potential for perched water to exist within the Made Ground, which may affect shallow excavations during particularly wet periods of weather. Groundwater levels in general are not expected to pose a risk to the proposed development.

Full ground gas and groundwater monitoring results are shown in Appendix E

6.0 GEOTECHNICAL ASSESSMENT AND RECOMMENDATIONS

6.1 Coal Workings

During the intrusive investigation although coal seams were encountered at shallow depths, there was no evidence of mine workings or voids in any rotary boreholes or trial pits, nor was there any evidence of mine gases being present. Where shallow coal was encountered, there was no evidence of bell pitting across the site. No remedial works related to mine workings are therefore deemed necessary for the site.

However, it is recommended that during the excavation works for the new foundations, a close eye is kept on all excavations to ensure that no evidence for mine workings does exist in the form of void migration. Additionally it should be ensured that the new building foundations must completely bypass any encountered coal seams.

6.2 Foundations

It is assumed that the site will be made level and the area in the South East corner of the site which is currently at a higher elevation to the rest of the site will be excavated to also make this area level with the rest of the site.

Following this, typical strip footings should be suitable for house Plots 1 to 7. The footings will have to be constructed beneath any Made Ground and original Topsoil which still remains following site clearance, and founded upon the granular Highly Weathered Bedrock. In reality final foundation depth will differ across the site, due to the variation in depth to this Highly Weathered bedrock, but it can be assumed that final foundation depth will be at approximately 1.0mbg to 1.40mbgl. The Highly Weathered bedrock is likely to provide allowable bearing pressures up to 200kN/m^2. It would be prudent to reinforce all footings.

The same foundation solution may apply also to house Plots 8 to 10, if no shallow coal is encountered. If shallow coal is encountered, then it may be necessary to utilise piled foundations to the intact bedrock at approximately 4.0mbgl.

All foundation excavations must be inspected to ensure that no footings are placed upon any existing weak Made Ground, softer Clays/Weathered coal seams, or any other weak materials that would be incapable of safely sustaining the applied foundation loads. This is particularly important wherever any appreciable amounts of Made Ground occur. Additionally all foundation excavations should be inspected

to confirm that the Weathered Bedrock has been encountered, and that no evidence of mine workings or void migration exists, therefore confirming that a suitable bearing stratum has been encountered. Should evidence of mine workings be encountered during excavation for these foundations, then a piled foundation solution may be necessary.

Wherever any suspect ground is encountered at proposed foundation level, then that footing must be deepened until a satisfactory bearing medium is obtained.

6.3 Retaining Walls

Some form of retaining wall or other retaining feature will be required along the Eastern site boundary as the site is at a lower elevation than Heckmondwike Road, which runs along the this boundary.

6.4 Buried Concrete

Six samples of the natural soils were tested for pH and Sulphate Content. These results returned pH values of 5.8 to 8.9 with water soluble sulphate measurements of 41mg/l to 290mg/l. A design sulphate class of DS-1 can be adopted along with an ACEC class of AC-2z.

6.5 Roads and Hardstanding

A new access road is proposed off of 'Spen View' to the North along the West of the site, feeding a number of car parking spaces which will serve the new houses. Following guidance from Interim Advice Note 73/06 Rev1 'Design Guidance for Road Pavement Foundations' (draft HD25) 2009 (IAN73/06, 2009), an estimated CBR value of 4% can be assumed for the underlying shallow soils that currently exist (based on a silty sandy CLAY). This figure can be used as a preliminary guideline value for the road and hard standing design.

During construction, the sub-grade formation should be proof rolled and inspected. Should localised soft areas of inadequate sub-grade be encountered at sub-formation level these should be excavated and replaced with adequately compacted capping material or sub-base.

6.6 Excavations

For any deep excavation in excess of 1.20m where vertical sides are necessary, trench supports should be provided as the shallow soils will not be self supporting for any appreciable length of time.

Although no groundwater seepages were noted at the surface, there is always the potential for trapped (perched) groundwater that can be released from areas of Made Ground when they are excavated. Additionally, seasonal variation in groundwater levels will occur, and groundwater may be shallower during winter months.

6.7 Existing Structures

No buildings were present on site, however there was evidence of the old pub building in the raised area situated in the South East corner of the site. This building was evident in parts of walls, exposed foundations and old service pipes. Where known underground structures exist, it is recommended that they should be excavated and replaced with a suitably compacted fill material.

6.8 Existing Drains and Services

Drains and possible buried service channels may lie around the site. It will be necessary therefore to ensure that all footings for the new houses are not sited directly over any of them, as they could eventually collapse and cause loss of strength to the foundation stratum. Wherever any redundant drains and other services channels are likely to underlie building foundations, they must be dug out and replaced by lean mix concrete, or compacted hardcore. Alternatively, long drainage runs can be grouted up, particularly where their alignments are uncertain but care is needed to ensure that no grout enters any live services. In the case of roads, they should be dug out and the areas backfilled with a suitably compacted fill.

6.9 Material Re-Use

Due to the mixed granular and cohesive nature of the Made Ground encountered during the Ground Investigation, it is considered at this stage to be unsuitable for structural re-use.

Specific classification testing will be required on samples of any material that is proposed to be re-used, in accordance with a relevant environmental/earthwork specification and approved for use by the local contaminated land officer.

7.0 GROUND CONTAMINATION – GENERIC QUANTITATIVE RISK ASSESSMENT

7.1 Scope of Sampling, Testing and Commentary

The following assessment was performed in the context of the planning regime and considering Part 2A of the Environmental Protection Act (1990) to determine if unacceptable risks to humans, vegetation or to specific parts of the wider environment are present on the site. The risk assessment follows the source, pathway, receptor methodology, as described in Contaminated Land Report (CLR) 11, which is used to build a conceptual site model to determine the presence of any pollutant linkages at the site. Should pollutant linkages exist at the site it is deemed necessary to further develop the risk assessment by comparing contamination test results with generic or site specific assessment criteria in order to determine if an unacceptable level of risk is present at the site. If legislation or guidance changes, or the proposed end use is modified, then it will be necessary to reassess the risks which may require further sampling and testing.

We understand our brief to comprise the following items related to the contamination aspects of this investigation.

- Compare laboratory test results with generic assessment criteria;
- Determine a conceptual site model and identify any pollutant linkages at the site;
- Determine the level of risk posed by environmental hazards on site to human health, vegetation, controlled waters and structures; and
- Make recommendations for further work or remediation strategies.

Soil samples were recovered in accordance with current industry practice and were sent to i2 Analytical Ltd to be analysed for the determinants listed in section 4.5 of this report.

The results of these analyses are included in Appendix D of this report.

7.2 Human Health Assessment

UK guidance recommends that a risk based approach is taken for the assessment of contaminated land and as such, DEFRA have introduced the CLEA methodology, SGV's and Category 4 Screening Values

(C4SL). The CLEA methodology is a deterministic risk assessment model that estimates the long term exposure to contaminants in the soil for children and adults and predicts the amount of contaminant to which a person might be exposed based on a given soil concentration. By comparison with relevant health criteria on tolerable or acceptable intakes of various contaminants the model was used by DEFRA and the Environment Agency to generate SGV's and C4SL's.

At the time of writing this report the DEFRA and Environment Agency has not published SGV's/C4SL using the CLEA 1.071 software for all anthropogenic toxic substances with C4SL's for further contaminants due to be produced at some point in the future. As such, it was necessary to use other methods to generate target concentrations for contaminants of concern on site.

In order to generate generic assessment criteria which are protective of human health, for use in human health risk assessment, where CLEA SGV's and C4SL's are not available the Environment Agency recommends the use of the CLEA 1.071 software in conjunction with advice found on the GOV.UK CLEA web pages. Accordingly, the Chartered Institute of Environmental Health (CIEH) in partnership with Land Quality Management (LQM) derived a set of Generic Assessment Criteria Values following the approach set out in the DEFRA research project SP1010, C4SL. The GAC for missing contaminants of concern were calculated using the CLEA 1.06 software released in July 2009 and termed Suitable 4 Use Levels (S4UL's). The input parameters used for calculating each S4UL value are listed in the substance specific chapters of the reference document associated with the S4UL's, namely 'The LQM/CIEH S4ULs for Human Health Risk Assessment (Land Quality Press, 2015).

The current view of the Environment Agency is that the C4SL's are considered to be a trigger value at which an exceedance may cause concern for human health and generally requiring further investigation and/or assessment. This report has utilised the C4SL's and CIEH/LQM S4UL's derived using the UK technical documents referenced on page 26.

The DEFRA C4SL and LQM/CIEH S4UL's for a residential with gardens land use has been selected as this matches the proposed future land use.

7.3 Vegetation Assessment

As the CLEA methodology only takes account of the risks to human health, a different approach is required to determine the risks to vegetation. In order to determine if levels of phyto-toxic contaminants in soil, not

normally considered to be harmful to humans, are suitable to maintain growth of vegetation the published reference values produced by the Ministry of Agriculture, Fisheries and Food (MAFF) have been used in this assessment.

8.0 DISCUSSION OF RESULTS

8.1 Human Health Hazards

The analytical results shown in Table 8.1 indicate that the Made Ground encountered across the site contains levels of contamination below the assessment criteria for the conservative land use of residential with gardens, in all cases except that of TP02 and TP08. In the Made Ground of TP02, elevated levels of Arsenic were measured above the assessment criteria levels. In the Made Ground of TP08, elevated levels of Arsenic, PAH and TPH were measured. It should be noted however, that TP08 was undertaken in an area of raised land which will have to be removed from site anyway, prior to construction. Additionally Asbestos was identified in the Made Ground sample of TP05 only.

Table 8.1 Comparison of Soil Test Results with Residential with Gardens C4Sl/S4UL

Determinant	Assessment Criteria (mg/kg)		Recorded Concentrations Across The Site (mg/kg)	
	C4SL Screening Levels	S4UL Generic Assessment Criteria	Highest Recorded Value	Location of Highest Recorded Value
Metals, semi- metals and non-metals				
Arsenic	37	37	73	TP08
Cadmium	17	11	0.8	TP03
Copper	NC	2400	100	TP08
Chromium Total	NC	910	72	TP08
Lead	210	NC	170	TP02
Mercury (elemental)	NC	1.2	0.4	TP08
Nickel	NC	130	35	TP06
Selenium	NC	250	<1	All
Vanadium	NC	410	55	TP02
Zinc	NC	3700	160	TP02
PAH (total)	NC	NC	241	TP08
TPH (total)	NC	NC	590	TP08
Naphthalene	NC	1.5	4.0	TP08
Acenaphthylene	NC	170	0.79	TP08
Acenaphthene	NC	210	3.6	TP08
Fluorene	NC	170	2.9	TP08
Phenanthrene	NC	95	37	TP08
Anthracene	NC	2400	5.60	TP08
Fluoranthene	NC	280	0.92	TP02
Pyrene	NC	620	0.91	TP02

Determinant	Assessment Criteria (mg/kg)		Recorded Concentrations Across The Site (mg/kg)	
	C4SL Screening Levels	S4UL Generic Assessment Criteria	Highest Recorded Value	Location of Highest Recorded Value
Benzo(a)anthracene	NC	7.2	22	TP08
Chrysene	NC	15	19	TP08
Benzo(b)fluoranthene	NC	2.6	0.63	TP02
Benzo(k)fluoranthene	NC	77	7.6	TP02
Benzo(a)pyrene	3.2	2.2	17	TP08
Indeno(1,2,3-c,d)Pyrene	NC	2.3	6.8	TP08
Dibenzo(a,h)anthracene	NC	0.24	2.0	TP08
Benzo(g,h,i)perylene	NC	320	7.1	TP02/TP08
Others				
Cyanide (total)*	NC	5	<1	All
Asbestos In Soil	NC		Detected	TP05

NOTES:
(1) C4SL/LQM S4UL 2015 for Residential with gardens land use scenario at 1% organic matter content
(2) *= Dutch Target value used as screening value for cyanide.
(3) NC = No criterion.

8.2 Vegetation Hazards

The concentrations of the various phytotoxic contaminants encountered in the Made Ground and natural soils shown in Table 8.2 indicate that an elevated level of Arsenic is present in the Made Ground of TP02 and TP08, along with an elevated levels of Copper in TP08.

Table 8.2 Soil Test Results Vs Phyto-Toxic Chemical Assessment Criteria

Determinant	MAFF Reference Value (mg/kg)		Recorded Concentrations Across Sampled Area (mg/kg)	
	Maximum Permissible Concentration		Highest Recorded Value	Location of Highest Recorded Value
	pH 5.0-5.5	pH >7		
Metals and semi- metals				
Arsenic	50	NL	73	TP08
Copper	80	200	100	TP08
Nickel	50	110	35	TP06
Zinc	200	300	160	TP02
Cadmium	3	NL	0.8	TP03
Lead	300	NL	170	TP02
Selenium	3	NL	<1	All

NOTES: (1) NL = indicates that no level has been set

8.3 Waste Acceptance Criteria

The Landfill Directive sets out procedures for waste acceptance at landfills and the type of waste for each class of landfill as specified by Waste Acceptance Criteria (WAC). The WAC are a list of 'limit values' for certain parameters obtained from standard leaching tests of wastes going to landfills. Full details can be found in Environment Agency 'Guidance for Waste Destined for Disposal in Landfills', Version 2, June 2006.

There is an area of raised ground in the South East corner of the site, which will need excavating and removing from site to landfill prior to construction. Two samples of the Made Ground from this raised area were collected and tested for WAC, with the full results shown in Appendix F.

Table 8.3 shows the results of this WAC testing and the limit values for Inert Waste.

Table 8.3 WAC Test Results

Determinant	Measured Concentration (mg/kg)	Limit Value for Inert Waste (mg/kg)
Leachate Component		
Arsenic	0.074	0.5
Barium	0.054	20
Cadmium	<0.01	0.04
Chromium Total	0.015	0.5
Copper	0.041	2
Mercuy	<0.0050	0.01
Molybdenum	0.069	0.5
Nickel	0.019	0.4
Lead	<0.010	0.5
Antimony	<0.017	0.06
Selenium	0.046	0.1
Zinc	0.040	4
Chloride	62	800
Fluoride	8.9	10
Sulphate	230	1000
Total Dissolved Solids (TDS)	870	4000
Phenol Index	<0.10	1
Dissolved Organc Carbon (DOC)	38	500
Waste Analysis		
Total Organic Carbon	4.2	3%
Loss on Ignition	12	
BTEX	<1	6
PCBs (7 Congeners)	<1	1

Determinant	Measured Concentration (mg/kg)	Limit Value for Inert Waste (mg/kg)
Mineral Oil (C10 – C40)	35	500
PAH – (WAC 17)	240	100

These results indicate levels of Total Organic Carbon marginally exceeding the limit for “Inert Waste”, although a higher limit value may be permitted, provided the Dissolved Organic Content is less than 500mg/kg, which is the case here.

Additionally levels of PAH were also found to exceed the limit for an “Inert Waste”.

These results indicate disposal of this material is likely to be within a Stable Non-reactive Hazardous Waste in Non-Hazardous Landfill.

9.0 CONCEPTUAL SITE MODEL

9.1 Introduction

The information obtained from the RB Geotechnical phase 1 desktop study as well as from this investigation has been collated and evaluated to develop a refined Conceptual Model for the site.

The site has been assessed in line with current UK guidelines, namely the Contaminated Land (England) Regulations 2000 and Part IIA of the Environmental Protection Act 1990 and follows the procedures set out in the Environmental Agency 'Model Procedures for the Management of Land Contamination – Contamination Land Report (CLR).11'.

CLR.11 provides the technical framework for structured decision making about land contamination and builds on previous work carried out under the Contaminated Land Research Programme of the former Department of the Environment. CLR 11 has adopted and refined the methodology and terminology that has been used in contaminated land risk assessment for a number of years.

CLR.11 defines the three essential elements to any risk:

- A contaminant **source** - a substance that is in, on or under land and has the potential to cause harm or to cause pollution of controlled waters;
- A **receptor** – in general terms, something that could be adversely affected by a contaminant, such as people, an ecological system, property or a water body; and
- A **pathway** - a route or means by which a receptor can be exposed to, or affected by a contaminant.

Each of these elements can exist independently, but they create a risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. This kind of linked combination of source-pathway-receptor is described as a **pollutant linkage**.

This report presents a Phase 2 Conceptual Model and Quantitative Risk Assessments for the site, based on the proposed conservative end use of residential with home grown vegetables.

9.2 Hazard Identification

9.2.1 Potential Contamination Sources

Historically the site was previously a pub with tarmac car parking area, and out buildings. All buildings have since been demolished, however there is still evidence of these buildings along with the car parking area.

The on-site sources of contamination identified were mainly from potentially contaminated soils beneath the car parking area as a result of fuel or oil leaks from parked vehicles. Additionally, Made Ground that was created as a result of the construction and demolition that has taken place across the site, was also considered another potential on-site source of contamination.

The intrusive ground investigation confirmed the presence of Made Ground across the whole site, extending to depths up to 1.60mbgl.

The North West corner of the site comprises an area of raised ground by approximately 1.0m. TP01 was carried out into this raised area, whereby it was established that the raised ground is Made Ground.

A summary of potentially significant sources of contamination are presented in Table 9.1.

Table 9.1 Summary of Contaminant Sources & Contaminants

Structure / Process	Contaminants Present on Site
On-site	
Made ground in areas of former buildings. Possible minor fuel spills and leaks in area of car park	• Elevated levels of metals recorded in TP02 (South West of site) and TP08 (South East Corner of site) • Elevated hydrocarbons recorded in TP08 • Asbestos detected in TP05 only (North East of site) • No sources of ground gas production identified
Off site Source: infilled land situated within 250m of the site	**Off-Site** • No elevated ground gas identified

9.2.2 Potential Receptors

The following are considered as potential receptors in relation to the current and proposed use of the site.

- **Future Residential users** – Female child aged 0-6 years using communal gardens;
- **Utility / Construction / Demolition / Site Investigation workers** – Workers undertaking routine / non-routine work involving ground disturbance works and maintenance of below ground services (assuming workers are only wearing standard construction / utility worker PPE);
- Underlying **Secondary A Aquifer** – Pennine Lower Coal Measures;
- **New potable water supply pipes**
- **Ingress of ground gases into structures**

9.2.3 Potential Contamination Pathways

The following are considered plausible contamination pathways given the nature of the site and the potential contaminative sources identified, and assuming a continued current use.

- Dermal contact and ingestions of soils;
- Inhalation of dust/fibres and vapours;
- Ingestion of home grown produce; and
- Risk from ground gases, asphyxiation or explosion.

9.2.4 Quantitative Risk Assessment

By considering the sources, pathways and receptors, an assessment of the environmental risks is made with reference to the significance and degree of the risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance.

An initial conceptual model of the source-pathway-receptor linkages has been developed based on the information derived from the RB Geotechnical Phase I desk study and this intrusive investigation. The Conceptual Site Model has been used to identify Relevant Pollutant Linkages for the current and proposed end uses which have been assessed quantitatively and qualitatively using CIRIA 552 guidance, as described in Table 9.2 and Table 9.3.

Table 9.2 Methodology for Assessing Consequence of Harm

Consequence	Criteria
Severe	Short term (acute) risk to Human Health likely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Short term risk of pollution of sensitive water resource. Catastrophic damage to buildings / property
Moderate	Chronic damage to Human Health likely, over a long term, to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Pollution of sensitive water resources
Mild	Health effects to Human Health that are unlikely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings / structures / services or the environment
Negligible	Non-permanent health effects to Human Health that are unlikely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Those that are easily prevented by means such as personal protective clothing. Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve.

Table 9.3 Methodology for Assessing Likelihood of Consequence Occurring

Probability	Criteria
Almost Certain	Circumstances are such that an event either appears very likely in the short term and almost inevitable over the long term or there is evidence of currently harm occurring
Likely	Circumstances are such that an event, whilst not inevitable, is possible in the short term and is likely to occur over the long term
Unlikely	Circumstances are such that it is possible an event could occur but it is by no means certain to occur even over a longer period, and it is less likely in the shorter term
Very Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable even in the medium to long term
Extremely Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are highly improbable even in the long term

The risk assessment table and apportioned scores presented in Table 9.4 are in general accordance with CIRIA 552. The main exception is that irreversible risks to human health are considered to have a severe consequence irrespective of whether the effects are chronic or acute in nature.

Table 9.4 Comparison of Consequence and Likelihood

Consequence / Probability	Severe	Moderate	Mild	Negligible
Almost Certain	Very High Risk	High Risk	Moderate Risk	Low Risk
Likely	High Risk	Moderate Risk	Moderate/ Low Risk	Low Risk
Unlikely	Moderate Risk	Moderate/ Low Risk	Low Risk	Very Low Risk
Very Unlikely	Low Risk	Low Risk	Very Low Risk	Very Low Risk
Extremely Unlikely	Very Low Risk	Very Low Risk	Very Low Risk	Very Low Risk

The categories of risk are defined as follows:

Very High Risk: There is a probability that severe harm is almost certain to arise to a designated receptor from an identified source, or there is evidence that severe harm to a designated receptor is currently occurring.

High Risk: There is a probability that severe harm is likely to arise to a designated receptor from an identified source, or there is a probability that moderate harm is almost certain to arise.

Low Risk: There is a possibility that harm could arise to a designated receptor from an identified source, but it is likely that this harm, if realised, would be mild at worst.

Very Low Risk: There is a very low possibility that harm could arise to the receptor, but it is likely that this harm, if realised, would be mild at worst.

In accordance with CLR11, professional judgement has been employed to evaluate the risk on a qualitative basis using available information.

A summary of the pollution linkages are provided in Table 9.5

Table 9.5 Conceptual Site Model (Revised Following Phase II Investigation)

Source	Receptor	Pathway	Risk	Pollutants Encountered/Chemicals of Concern	Remedial Option(s)/Next Steps
On Site: Made Ground in areas of former buildings, possible minor fuel spills and leaks in car park area.	Residential Home Owners	• Dermal contact or ingestion contaminants in soil-derived dust and entrained surface water run-off from areas where soil is exposed at the surface or where excavation takes place and in shallow groundwater in the natural strata if excavation takes place below the water table. • Inhalation of contaminants in soil derived dust from areas where soil is exposed at the surface of where excavation takes place. • Inhalation of soil and water derived vapours and ground gas outdoors • Inhalation of soil derived and water derived vapours and ground gas indoors where it may have accumulated in buildings and enclosed spaces.	Moderate/Low	Elevated levels of Arsenic above assessment criteria encountered in TP02 (South West corner of site). Also elevated levels of Arsenic and hydrocarons in TP08 (South East corner of site) Asbestos detected in TP05 in North East corner of site	The elevated levels of Arsenic above the assessment criteria were encountered in TP02 which is situated in an area of proposed access road, which will be beneath proposed harsdstanding. No remediation actions are therefore required in this area. The elevated levels of Arsenic and hydrocarbons in TP08, are situated in the proposed back garden areas of Plots 8 and 7. Remedial actions required. Discussed in more detail in section 9.4. Asbestos detected in TP05 in North East corner of site (close to footprint of Plot 1 and Plot 2). Remedial actions required. Discussed in more detail in section 9.4.
	Construction Workers		Low		All construction workers should ensure that correct PPE is worn to mitigate any unforeseen risks
Off Site: Infilled land features within 250m of site boundary.	Groundwater within the Pennine Lower Coal Measures (Secondary A Aquifer)	• Leaching of contaminants and/or migration of free phase contaminants from the unsaturated zone soils to groundwater in the natural strata • Vertical migration of contaminants in shallow groundwater to deeper strata and aquifer	Very Low	No Further Assessment Required	
	Surface Water	• Lateral migration of contaminants and/or migration of free phase contaminants present in the Made Ground via groundwater to surface water discharge • Lateral migration of contaminants and/or migration of free phase contaminants present in the Made Ground and entrained in surface water runoff	Very Low	No Further Assessment Required	
	Building	• Accumulation of soil and water derived vapours/and or ground gas in enclosed spaces	Very Low	No Further Assessment Required	

9.3 Discussion of Risks

The risk assessment presented in the above sections and summarised within the CSM presented in Table 9.5 shows that theoretical Contaminant Linkages were identified to be present at the site. The following sections provide a discussion of the environmental risks based on the ground investigation and laboratory data as well as the desk study information.

9.3.1 Human Health

Proposed residential property users

The ground investigation and laboratory testing showed that the Made Ground in TP02, situated in the South West corner of the site, contained elevated levels of Arsenic above the assessment criteria. This Trial Pit was carried out in an area currently proposed to be covered by tarmac hardstanding and is therefore not deemed a risk.

Elevated levels of Arsenic and hydrocarbons were measured in TP08, situated in the South East corner of the site by the proposed back gardens of Plots 7 and 8. This material is to be removed from site prior to construction during the process of finalising site levels. This would therefore likely act as the main remedial action here.

Asbestos was identified in TP05, situated in the North East corner of the site localised to the proposed back garden of Plot 1. Remedial measures will be necessary in this back garden area.

Therefore the risks to human health has been assessed to be **MODERATE/LOW**.

Utility / Construction / Demolition / Site Investigation (i.e. Ground Disturbance) Workers

The probability of contact with contaminated soils increases for workers involved with ground excavation (e.g. during development, site investigation or maintenance works). However, due to the exposure time to contaminants on site and the assumption that appropriate PPE will be worn the risks to site operatives is considered **LOW**.

9.3.2 Secondary A Aquifer

The risks to the underlying aquifer has been assessed to be **VERY LOW.**

9.3.3 Surface Water

The risk of contaminants to controlled waters is considered to be **VERY LOW**.

9.3.4 Structures Ground Gases/Vapours

Sources of ground gas production were identified during the ground investigation in coal seams and Made Ground. Ground gas monitoring undertaken over a period of time indicated that no elevated levels of ground gases were present on site.

The level of risk from ground gases was therefore assessed to be **VERY LOW.**

9.3.5 Potable Water Supply Pipes

Due to the low levels of contamination across the majority of the site it is unlikely that specialist pipe material will be required to mitigate the risks from contaminants following the recommended remedial works. The risks to new potable water pipes is therefore considered to be **VERY LOW**.

It is recommended to consult with the statutory water supplier in order to ascertain their requirements.

9.4 Remedial Options

Some contamination has been identified in and around the South East corner of the site around the back garden areas of proposed Plot 7 and Plot 8. Arsenic and hydrocarbon levels here were measured above the allowable assessment criteria level. The following remedial action is deemed suitable.

- Following complete removal of the material which makes up the raised area in the South East corner of the site, it is recommended that any remaining Made Ground (up to 0.30m) in the back garden areas of Plot 7 and Plot 8 also be excavated and replaced with a suitable imported material, in addition to placement of 600mm of clean Topsoil.

Additionally asbestos was identified within the Made Ground of TP05, situated in the North East corner of the site localised in the proposed back garden area of Plot 1. The following remedial action is deemed suitable:

- Excavate a suitable depth of the Made Ground (to 0.60mbgl), in front and back garden areas to Plot 1, and replace with a suitable imported material, in addition to placement of 600mm of clean topsoil..

10.0 CONCLUSIONS

The Phase I Desk Study identified potential on-site and off-site sources of contamination. On-site sources of contamination were identified as potential contamination within the Made Ground around any historical buildings, or contamination from potential fuel/oil leaks in the car parking area. Off-site sources of contamination were identified mainly as potential ground gases from infilled land features historically mapped within 250m of the site boundary.

An intrusive investigation was therefore carried out across the site comprising machine excavated trial pitting, enabling suitable sampling of the shallow Made Ground soils and necessary laboratory testing for potential contaminants. Additionally, samples were collected from the natural soils, to allow an assessment for geotechnical recommendations to be carried out.

The shallow Made Ground was tested for a range of contaminants. Two samples were found to contain contaminants which require potential remedial actions. In TP08, situated in the South East corner of the site (in proposed back garden of Plot 7 and Plot 8), the Made Ground sample was found to contain elevated levels of Arsenic and hydrocarbons which were above the allowable criteria levels. As this is in an area of raised ground, which will be removed from site prior to construction, the majority of this contaminated Made Ground will therefore already have been removed. Therefore it is recommended that any remaining Made Ground in these garden areas (to 0.30m), should also be excavated and replaced with a suitable material.

Asbestos was identified in the Made Ground of TP05, situated in the North East corner of the site, localised to the proposed back garden of Plot 1. It was recommended that all Made Ground in the proposed back and front gardens be excavated to a depth of 0.60mbgl and replaced with a suitable imported Topsoil.

The natural ground profile encountered, has resulted in the recommendation for typical strip footings placed into the granular weathered bedrock, with depths likely to vary across the site, but expected at 1.0mbgl to 1.40mbgl, whereby bypassing any deep Made Ground and soft spots onto a stratum where a suitable bearing capacities can be achieved. Should shallow coal seams be encountered (possibly in area of Plots 8, 9 and 10), then a piled foundation solution may be required to the intact bedrock.

On top of this, four Rotary Open Hole Boreholes were carried out across the site to assess whether there was any evidence of mine workings in the coal seams beneath the site. Additionally, gas and groundwater monitoring standpipes were installed into three of these boreholes, to allow gas monitoring over a six week period, assessing whether the site is at risk of ground gas pollution.

During the Rotary Open Hole drilling, it was confirmed that there was no evidence of mine workings, voids or void migration within any of the coal seams encountered. Additionally, there was no evidence of voids or void migration in any of the machine excavated trial pits, nor was there any sign of bell pitting across the site. No remedial measures are therefore deemed necessary in relation to potential mine workings. It is however recommended that a close eye is kept on all excavations carried out on site to ensure that no further evidence of mine workings is encountered. Should there be evidence of void migration in any future excavations, then alternative foundation options may be necessary.

Six gas and groundwater monitoring visits were carried out following the intrusive investigation. No elevated levels of ground gas were identified, therefore no gas remedial measures are deemed necessary. Additionally on all occasions, no groundwater was measured, so is assumed to be at a depth which poses minimal risk to the proposed development.

11.0 RECOMMENDATIONS

Along with the recommended remedial measures stated in section 10, the following works are also recommended:

- A clean cover system should be applied to all garden areas where Made Ground exists. This clean cover should consist of a minimum of 600mm of clean topsoil and sub-soil. This is in accordance with the recommendations in the joint NHBC, Environment Agency and Chartered Institute of Environmental Health publication "Guidance for the Safe Development of Housing on Land Affected by Contamination" published in 2008. Where natural ground exists in garden areas, no special precautions are considered necessary.

12.0 REFERENCES

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