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SUMMARY

Site Details	
Site Location	<i>The site is located circa 0.91 miles south west of Prescott Town Centre and is approximately centred on National Grid Reference 346080, 392010.</i>
Site Area	<i>The site is roughly square in shape and circa 3.48 hectares in area. The topography is very uneven coming to an elevated point in the centre of the site.</i> <i>The site is currently formed by a vacant piece of land and covered by overgrown vegetation and semi-mature to mature trees. Japanese Knotweed is known to the site and is situated mainly in the east of the site.</i> <i>A potential mine shaft indicator (concrete pyramid marker) enclosed by a chain link fence is present in the west of site.</i>
Ground Model	
Made Ground	<i>Made Ground was encountered beneath the site to a maximum depth of 4.5m bgl.</i> <i>The Made Ground generally consisted of brown clayey gravelly sand, brown occasionally orange/yellow clayey sandy gravel and brown gravelly sandy clay with minor constituent of glass, plastic, wood, concrete, brick, ceramics, and metal.</i> <i>Colliery spoil was encountered within TT10, TT11 TT12, and TT18 which are located around both of the unidentified mine shaft locations, as well as within TP02, WS02, WS03, WS03A, WS05, WS08, and WS09.</i>
Natural Soils	<i>Soft Clay was present in TP07 to TP09, TP29, TT02 and WS11 to depths of between 1.2m and 4.0m bgl. Firm and stiff Clay was in TT03 to TT09, TT12 to TT16, TT18 to TT20, WS03A, TP01, TP07, TP08, TP11, TP13, TP15, TP20, TP26, TP28 and TP29 to depths of between 3.4m and 5.9m bgl.</i> <i>Clay was recorded in R02 to R04 to depths of between 9.2m and 13.3m where bedrock was encountered.</i> <i>Brown gravelly clayey fine to coarse Sand was present in TP02, TP04, TP07, TT07, TT08, TT10 and TT11 to a maximum depth of 5.5m bgl.</i>
Bedrock	<i>Bedrock was encountered in R01 to R04 from depths between 4.5m and 13.3m and generally consisted of interbedded sandstone, siltstone and mudstone to depths of up to 30.0m bgl where the holes terminated.</i> <i>A thin seam of Coal was encountered within R03 between 22.5m to 22.55m bgl.</i>
Groundwater	<i>No groundwater was encountered throughout the Ground Investigation.</i>
Ground Engineering	
Mine Shafts / Coal workings	<i>A concrete cap was encountered on the location of SHAFT346392-001 in the north of the site when excavating TT01. The top of the cap was at 1.4m bgl and the dimensions were 6.0m x 6.8m and was 0.8m in thickness.</i>

Foundations	SHAFT346391-015 and SHAFT346391-016 are positioned along the eastern site boundary, trial trenches (TT02 to TT20) were excavated in this area and in the surrounding areas and no evidence of the concrete caps were observed. No evidence of workings were encountered during the intrusive investigation, further investigation is recommended to confirm the risk is low. The Bastions Coal and the Tenlands Coal were also generally absent beneath the site. The most suitable solution for the proposed development in the southern area is considered to be a Vibro Stone Columns (VSCs) to a partial depth with a reinforced raft foundation above. As an alternative, piled foundation may also be a viable option, transferring loads through the Made Ground and natural Clay and Sand deposits to bedrock which has been encountered from depths of between 4.5m and 13.3m bgl. In the northern area, the site requires turning over to remove obstructions. The Made Ground and concrete obstructions requires processing and placing to an end product/performance specification. On completion of the earthworks, it is recommended that VSCs are installed with a reinforced strip foundations.
Concrete	As the soils beneath the site are potentially pyritic, the concrete classification for the site is ACEC Class AC-4 and sulphate class DS-4.
Highways/Pavements	Untreated Made Ground should be assumed to have a CBR value of less than 2.5%, unless proven otherwise.
SuDS	The use of SuDS drainage is not considered to be a feasible option as the site is predominantly underlain by deep Made Ground which is contaminated and underlain by natural cohesive ground. The main limitation for the development is the mine shafts, specifically the shaft beneath the northern area that requires investigating and treating. Deep Made Ground and soft Clay was encountered locally to depths of 4.5m bgl. Japanese Knotweed is present on the site which will need to be treated or removed prior to construction commencing. The soils beneath the site are potentially pyritic and therefore the concrete classification is ACEC Class AC45 and sulphate class DS-4 which may make the use of concrete piles uneconomical. In addition, contaminated soils are present beneath the site which have been classified as being hazardous therefore, bored piles are unlikely to be an economical option due to the need to remove arisings offsite. Obstructions particularly below the northern area of the site require grubbing up as part of the enabling works.
GQRA and Revised (PL) Assessment	
Human Health	Elevated levels of heavy metals including arsenic, lead, mercury and nickel were recorded by the Ground Investigation. Speciated PAHs and asbestos fibres were also encountered within the Made Ground soils beneath the site. The risk to Human Health is considered to be Moderate to High.

Controlled Waters	<i>Significant mobile contamination has not been encountered and the risk to controlled waters is considered to be Low.</i>
Permanent Ground Gas	<i>Three ground gas monitoring visits have been completed and based on the current results the site has been classified as being in Characteristic Situation 2. At present, the risk from permanent ground gases is Moderate to High and will be confirmed on completion of the gas monitoring where either CS1 conditions will be required or the site will be zoned to incorporate CS1 and CS2 conditions.</i> <i>The latest radon maps launched by UKHSA indicate the northern part of the site to be in an area where the maximum radon potential is 3% to 5% and basic radon measures may be required within new buildings. It is recommended that a site-specific search is carried out through the BGS to determine the exact level of precautions required.</i>
Final Appraisal	

The following further work is required to progress the project to development phase:

- *Completion of gas monitoring programme.*
- *Issue gas assessment.*
- *Commission a site-specific radon search through the BGS to confirm the level of precautions required.*
- *Further investigation to determine the presence of workings, specifically in the northern area.*
- *Investigation of the mine shaft on the northern area to inform treatment including to determine the depth to bedrock around the shaft.*
- *Combustibility testing.*
- *Further BRE testing to reduce concrete classification.*
- *Further investigation of inaccessible areas due to vegetation/ecology.*
- *Treatment or removal of Japanese Knotweed.*
- *Preparation of a Remedial Specification.*
- *Watching brief during enabling works particularly below obstructions associated with sewage disposal works and associated tanks/filter beds.*
- *Confirmation of the recommendations made within this report with regulators.*

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Plans

<i>Plan Reference</i>	<i>Revision</i>	<i>Title</i>
GRO-22463-P01	-	Project Location Plan
GRO-22463-P02	-	Preliminary Development Constraints Plan
GRO-22463-P03	-	Exploratory Hole Location Plan
GRO-22463-P04	-	Generalised Ground Model
GRO-22463-P05	-	Contamination Plan
GRO-22463-P06	-	Illustrative Revised CSM
GRO-22463-P07	-	Coal Outcrops Plan
GRO-22463-P08	-	Foundation Constraints Plan

1.0 INTRODUCTION

1.1 Project Objectives

Groundtech Consulting Limited have been instructed by Partner Construction Ltd to undertake a Geo-Environmental Appraisal for a site at Carr Lane in Prescot.

A main investigation was undertaken in accordance with BS 5930:2020, BS 10175:2017, BS 8576:2013, CIRIA C758 and Eurocode 7 to revise the CSM and quantify the level of risk identified in the PRA. The Appraisal has been prepared in accordance with current UK Legislation and to discharge Land Quality pre-commencement planning conditions.

The report has been undertaken to fulfil the requirements of a preliminary risk assessment in accordance with current LCRM risk assessment guidance.

Phase 1 and Phase 2 Geo-environmental Site Assessment referenced 14-245-R1, dated February 2021 has been prepared for the site by e3p and should be read in conjunction with this appraisal.

1.2 Development

The proposed development is residential end use comprising the construction of dwellings including soft landscaped gardens and hardsurfaced access roads and driveways.



Proposed Development

1.3 Limitations

Other conditions may exist on the site that have not been taken into account in this assessment as they are outside the scope of works. Groundtech Consulting are not responsible for these circumstances that are not outlined in the report.



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2.0 SITE SETTING

2.1 Location

The site is located circa 0.9 miles south west of Prescott Town Centre, as shown on the Project Location Plan GRO-22463-P01 and is approximately centred on National Grid Reference 346080, 392010.



Access to the site is gained off Prescott Park Way to the north east.

2.2 Site Description

The site is roughly square in shape and circa 3.48 hectares in area. The topography is very uneven with the most elevated point in the centre of the site.

Site Features

The site is currently formed by a vacant piece of land and covered by overgrown vegetation and semi-mature to mature trees. It is evident that areas of the site are self-seeded from the more dense mature vegetation around the perimeter and through the centre of the site. Japanese Knotweed is present on the site, stands have predominantly been identified on the eastern area, the ecological survey will confirm location and coverage.

A likely mine shaft indicator (concrete pyramid marker) enclosed by a chain link fence is present in the south western corner of the site. The concrete slab and marker abut the southern boundary of the site with a footpath on the opposite side of the fence to the south.

The site is well trodden, and footpaths are noted throughout, indicative of frequent dog walking and pedestrian use. Locally trees have been cut down and evidence of localised fires were noted.

Site Boundaries and Surrounding Land Uses

The north and west site boundaries are formed by dense vegetation, a noise bund is along the eastern boundary and a metal fence is to the south.

The site is surrounded by the following land uses/features:

- North - Prescott Park Way.
- East - Residential land use.
- West - Prescott Brook.
- South - M57 motorway.

Photographs are presented in *Appendix 2* and relevant features are recorded on the Preliminary Development Constraints Plan *GRO-22463-P02*.

3.0 PHASE 1 AND PHASE 2 SITE ASSESSMENT SUMMARY

A Phase 1 and Phase 2 Site Assessment referenced 14-245-R1, dated February 2021 was previously produced by e3p and the findings are summarised in the following sections. Groundtech Consulting are not responsible for any of the recommendations in this section.

3.1 Site History and Consultations

Site History

Historical mapping suggests that southern area of the site is the former location of Old Carrs Pit and associated pumping station, a shaft is positioned to the southern end of the site.

Between the 1960s and 1990s, the south was utilised as a refuse tip. Prescott Brook runs along the western boundary of the site and the area itself is marked with sporadic trees and rough pasture throughout. A public footpath runs along the eastern boundary of the site.

From the early 1920s, the northern area of the site is part of the Prescott Sewage Disposal Works and features sludge beds, storm tanks, screen chambers, settling tanks, filter beds, pumps and humus tanks. An area to the centre of the site is marked as hardstanding and part of Old Carrs Pit. From 1950s, a number of drains are marked through the sewage disposal works with the hardstanding area no longer marked, embankments are present surrounding the works and the western boundary.

By the late 1990s the works features are no longer present.

Consultations

The following environmental information was identified:

- *The site is not within an area requiring radon protective measures.*
- *There is 1 active industrial authorised process within 500m of the site.*
- *There have been six minor pollution incidents within 500m of the site.*
- *There is a historic landfill onsite named Prescott Wastewater Treatment Works as well as the southern area of the site being utilised as a refuse tip pre 1966, and two historic landfills within 500m of the site.*
- *There are thirty-three sewage discharges located within 500m of the site, they have all been revoked/ceased/surrendered.*
- *There are no petrol stations within 500m of the site.*
- *Four historic mine shafts are located on the site.*
- *An opencast quarry is identified within the south of the site.*

3.2 Geology and Hydrogeology

Geological maps did not indicate the presence of any Made Ground beneath the site, however it was anticipated to be present due to past uses of the site.

The superficial deposits underlying the site are indicated to be Glacial Till which characteristically comprises a mixture of clay, silt, sand, and gravel and is classified as a Secondary Undifferentiated Aquifer.

The site is indicated to be underlain by the Pennine Lower Coal Measures Formation comprising Mudstone, Siltstone, Sandstone and Coal seams and is classified as a Secondary A Aquifer.

The site is not indicated to lie within 500m of a Source Protection Zone and there are no potable water abstractions located within 2000m of the site. There are no groundwater abstractions located within 500m of the site.

Hydrology

The nearest named watercourse is Prescott Brook located 0m west of the site. There are no active surface water abstraction licenses within 500m of the site.

3.3 Coal Authority Consultation

The site lies in an area where the Law Society and Coal Authority recommends a mining consultation is undertaken due to past or current mining possible affecting the site.

Past Mining

The property is in the likely zone of influence from workings in 2 seams of coal 7m to 128m depth, last worked in 1930.

Any ground movement from these workings should have now stopped.

Mine Entries

There are five known coal mine entries on or within 20m of the site boundary.

Development High Risk Area

The site is within a Development High Risk Area.

Past or Probable Unrecorded Shallow Workings

The site is deemed to be at a high risk of shallow workings and associated risks from the mine entries on site. Therefore, a detailed mining investigation is required.

The Phase 1 and 2 Report issued by e3p states that throughout the intrusive investigation, no evidence of worked coal seams within influencing distance of the surface of the site were found. Therefore, the risk to the proposed development from shallow mining is considered to be low.

3.4 Preliminary Conceptual Site Model

The following risks were identified by e3p:

Receptor	Risk
<i>Site End Users from Contaminated Soils</i>	<i>High Risk</i>
<i>Site End Users from Inhalation of Vapours</i>	<i>High Risk</i>
<i>Site End Users from Inhalation of Gas</i>	<i>High Risk</i>
<i>Controlled Waters</i>	<i>Medium Risk</i>

3.5 Scopes of Works and Rationale

The following scope of works was completed between the dates of 28th September and 3rd November 2020:

- *Twenty-Three Trial Pits (TP101-TP123) were taken to depths of between 0.5m and 4.5m bgl.*
- *Four Rotary Open Holes (RB101-RB104) were taken to a maximum depth of 40.0m bgl.*

- *Thirteen Windowless Sampling Holes (WS101-WS112) were taken to depths of between 2.0m and 5.45m bgl.*
- *Sixteen Trial Trenches (TT101-TT116) were excavated to depths of between 1.5m and 4.0m bgl.*
- *Four Cable Percussive Holes (CP101-CP104) were taken to depths of between 6.65m and 9.5m bgl.*

3.6 Ground Model

Made Ground deposits were encountered in all exploratory hole locations to depths between 0.5m and in excess of 5.45m. The full depth of Made Ground could not be proven in 18 locations due to concrete obstructions or rapid water ingress.

Where the depth of Made Ground was proven, drift deposits generally comprised a firm to stiff, medium strength, brown slightly gravelly sandy Clay with gravel of sandstone and mudstone with occasional areas encountering brown silty fine to medium Sand with occasional areas encountering Clay pockets.

The solid bedrock geology was encountered between 6.0m and in excess of 9.7m bgl, becoming deeper in the northern sector of the site. The solid geology comprises grey/brown Mudstone which is underlain by grey Siltstone. Occasional Sandstone bands were noted within RB102 and RB104.

Coal was not identified within any exploratory hole locations. Mudstone with coal traces has been identified between 9.3m and 10.4m bgl, 27.6m and 28.4m bgl within RB101, between 9.8m and 10.9m bgl, 12.0m and 13.0m bgl in RB102 and 8.4m and 9.8m bgl in RB104.

3.7 Environmental Testing Results

The majority of samples tested for were below laboratory detection limits however the following contaminants were found at concentrations in exceedance of the residential Screening Guideline Values (SGV):

- | | | |
|--------------------------|---|---|
| • Arsenic | - | TP114 at 0.3m bgl and TP122 at 1.0m bgl. |
| • Lead | - | TP106 at 1.4m bgl, TP114 0.3m bgl, TP117 at 1.0m bgl, TP122 at 1.0m bgl, and WS109 at 3.4m bgl. |
| • Mercury | - | WS109 at 3.4m bgl. |
| • Nickel | - | TP122 at 1.0m bgl. |
| • Benzo(a)anthracene | - | WS106 at 0.80m bgl. |
| • Benzo(b)fluoranthene | - | TP108 at 0.50m bgl, TP117 at 1.00m bgl, WS108 at 0.1m bgl, and TP122 at 1.0m bgl. |
| • Benzo(a)pyrene | - | TP108 0.5m bgl, WS106 at 0.80m bgl, TP117 at 1.0m bgl, and WS108 at 0.1m bgl. |
| • Dibenzo(a,h)anthracene | - | TP105 at 0.3m bgl, TP108 at 0.5m bgl, TP117 at 1.0m bgl, WS106 at 0.8m bgl, and WS108 at 0.1m bgl. |
| • Asbestos fibres | - | Chrysotile and Amosite between <0.001 and 0.288 %mass in TP105 at 0.3m bgl, WS106 at 0.8m bgl, and WS108 at 0.1m bgl. |

3.8 Gas Monitoring

A completed phase of ground gas monitoring confirmed that the site can in part be classified as CS1, and in these areas it is considered that gas protection measures will not be required. However, localised areas

within the north and central areas of site have been assessed as being CS2 and properties within this area will likely require specialist protection measures in a zoned approach with approval from local planning.

3.9 Proposed Foundation Designs

Significant remediation and enabling works will be required across the site to remove Japanese Knotweed infested soils, stabilise worked seams of coal, remove obstructions in the Made Ground and create the required development platform. Therefore, the use of shallow foundations was considered to be limited.

Trees present on site and around the periphery must be considered in order to mitigate the potential for volumetric instability within cohesive soils where trees are to be removed and retained.

Soft cohesive deposits have been identified, subject to enabling works and levels the upper soft deposits could be excavated and replaced with granular fill, this would also mitigate tree influence for vibro to support a double reinforced spread footing. Where only partial depth treatment is achieved a raft or specific structural detail will be required to mitigate any associated settlement issues with untreated fills.

Where Peat is present, (WS105 and WS112) and soft Clay (TP122) these areas will require excavation or deepened foundations.

Piles are not likely to be viable given the mining risks associated with point loads over workings.

It is considered that the optimum foundation solution will be a combination of vibro, trench fill and raft. The final foundation solution can only be defined once development levels are available to fully appraise the depth to suitable founding stratum.

No Build Zones are present on site surrounding the mine entry features. Currently, only one shaft has been identified through a concrete marker and fencing, the remaining features will require probing to locate in order to design appropriate layouts.

4.0 SCOPE OF INVESTIGATION AND RATIONALE

4.1 Project Objectives

The aim of the Groundtech Consulting fieldwork was to:

Determine the stratification beneath the site.
Maintain a watching brief for visual and olfactory evidence of contamination.
Obtain samples using methodology in current guidance for contamination analysis.
Identify realistic pollution linkages to groundwater.
Install monitoring standpipes for gas level monitoring.
Assess the identified pollution linkages in the CSM.
Identify the location of mine shafts.
Determine the depth to Bedrock.
Investigate the presence of possible shallow coal workings.

4.2 Scope of Works

Two phases of Ground Investigation were undertaken between the dates from 6th June to 9th June and 10th July to 13th July 2023.

The following scope of works was undertaken between 6th June and 9th June 2023:

- 14 No. windowless sample boreholes (WS01 to WS12) were drilled to depths between 0.6m and 5.0m bgl.
- 4 No. Rotary Open Hole boreholes (R01 to R04) were drilled to a depth of 30.0m bgl.
- 22 No. Trial Pits (TP01 to TP04, TP06 to TP11, TP13, TP15 to TP17, TP20, TP22 to TP23, TP25 to TP29) were excavated to depths between 2.1m and 4.4m bgl.
- Surveying of all exploratory holes.

The following scope of works was undertaken between 10th July and 13th July 2023:

- 20 No. Trial Trenches (TT01 to TT20) were excavated to depths between 2.2m to 5.9m bgl.
- Surveying of all Trial Trenches and identified Mine Shaft Locations.

The surveyed exploratory hole locations are presented on Groundtech Plan GRO-22463-P03 and the exploratory hole logs are in Appendix 3.

The exploratory holes were positioned to establish the stratification beneath the site, and target areas of concern as summarised in the table below:

Location	Target Rationale
R01 to R04	Depth to bedrock within the opencast quarry and identify shallow coal workings
TP03, TP04, TP08, TP25	Identify mine shaft locations
TP06, TP09, TP11, TP12, TP15, TP16	Identify the quarry high wall
TP20, TP22, TP23, TP26 to TP29, WS07 to WS12	Identify historic foundations
WS02, WS03A, WS05, WS07 to WS09, WS11, WS12	Monitoring of ground gas
TP01, TP02, TP07, TP10, TP17, WS01 to WS06	General site coverage

The exploratory holes were logged by a suitably experienced geo-environmental engineer in general accordance with the following current guidance:

- BS 5930 'Code of Practice for Site Investigations' 2020.
- BS EN 14688-1:2002 'Geotechnical Investigation and Testing – Identification and classification of soil'.
- BS EN ISO 14689:2002 'Geotechnical investigation and testing – Identification and classification of rock'.

4.3 Soil Sampling

During the intrusive investigation, representative samples were taken at regular intervals, changes of strata and where evidence of contamination existed. Laboratory analysis was scheduled on the samples obtained.

The samples obtained are summarised in the table below:

Soil Sample	Number
Environmental Sample	159
Disturbed Sample	29
Undisturbed U100 Sample	1

The samples have been obtained in accordance with current environmental and geotechnical guidance. The sampling plan has been designed to obtain samples from all required strata using the correct methodology.

Disturbed samples of soil for geo-environmental testing were placed in the correct sampling containers as required by the laboratory in accordance with their MCERTS and UKAS Accreditation. Transportation was arranged in a timely manner and the samples were at the correct temperature.

The sample locations and depths are recorded on the exploratory logs.

4.4 Geo-Environmental Testing

To inform the Generic Quantitative Risk Assessment, the following geo-environmental testing was scheduled to assess the risk from contamination on the site. The testing is based on the potential sources identified in the PRA and observations during the Ground Investigation.

Contaminant of Concern (CoC)	Matrix	Number
<i>Arsenic, Cadmium, Chromium (total and Hex), Copper, Nickel, Mercury, Lead, Zinc, Selenium, Water Soluble Boron total and free cyanide, total sulphate, sulphide, sulphur, pH, speciated PAH (16), phenols, thiocyanate</i>	<i>Soil</i>	<i>35</i>
<i>Asbestos Screening</i>	<i>Soil</i>	<i>35</i>
<i>Asbestos Quantification</i>	<i>Soil</i>	<i>8</i>
<i>Total Petroleum Hydrocarbons (TPH CWG)</i>	<i>Soil</i>	<i>10</i>
<i>Volatile Organic compounds by GC-MS (ex TIC)</i>	<i>Soil</i>	<i>15</i>
<i>Semi-Volatile Organic compounds by GC-MS (ex TIC)</i>	<i>Soil</i>	<i>15</i>
<i>pH and Soluble Sulphate (2:1)</i>	<i>Soil</i>	<i>7</i>

The Geo-Environmental Laboratory Testing Results are presented in *Appendix 4*.

Representative disturbed samples were obtained for all soil types encountered. Selected samples were scheduled for testing at an approved laboratory in accordance with BS 1377 'Method of Test for Soils for Civil Engineering Purposes' 1990. The following tests were scheduled:

British Standard	Test Method	Number
<i>Part 2</i>	<i>Water Content</i>	<i>8</i>
<i>Part 2</i>	<i>Plasticity Index Analysis</i>	<i>8</i>
<i>Part 7</i>	<i>Quick Undrained Triaxial</i>	<i>1</i>

The Geotechnical Laboratory Testing Results are presented in *Appendix 5*.

4.5 Gas and Groundwater Monitoring

Gas monitoring installations were constructed in the boreholes. The standpipes consisted of polyvinyl chloride (PVC) pipe - a bentonite seal was placed around the plain pipe and a clean gravel pack was placed around the slotted pipe. A summary of the installation construction is presented in the table below:

Location	Depth (m bgl)	Response Zone (m bgl)	Targeted Strata	Reason
<i>WS02</i>	<i>1.00</i>	<i>0.50 - 1.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS03</i>	<i>4.00</i>	<i>1.00 - 4.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS05</i>	<i>3.00</i>	<i>1.00 - 3.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS07</i>	<i>1.00</i>	<i>0.50 - 1.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS08</i>	<i>4.00</i>	<i>1.00 - 4.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS09</i>	<i>3.00</i>	<i>1.00 - 3.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS11</i>	<i>4.00</i>	<i>1.00 - 4.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>
<i>WS12</i>	<i>1.00</i>	<i>0.50 - 1.00</i>	<i>Made Ground</i>	<i>Ground Gas</i>

Permanent gas and flow rate monitoring was carried out using a GFM 436 infrared gas monitor with integral electronic flow analyser. The measurements taken are listed below:

- *Oxygen (O₂), carbon dioxide (CO₂) and methane (CH₄) as the percentage volume in air (%v/v).*
- *Hydrogen sulphide (H₂S) and carbon monoxide (CO) as the percentage volume in air (%v/v).*
- *Lower Explosive Limit (%LEL) of methane.*
- *Atmospheric and borehole pressure, including pressure trend.*



- *Flow measurements (l/hr).*
- *Weather conditions.*

Both peak and steady state conditions were monitored to understand the behaviour of the permanent ground gas, the steady state conditions were recorded by allowing the gas monitor to run for a minimum of 3 minutes.

Interim permanent gas and groundwater monitoring results are presented in *Appendix 6*.

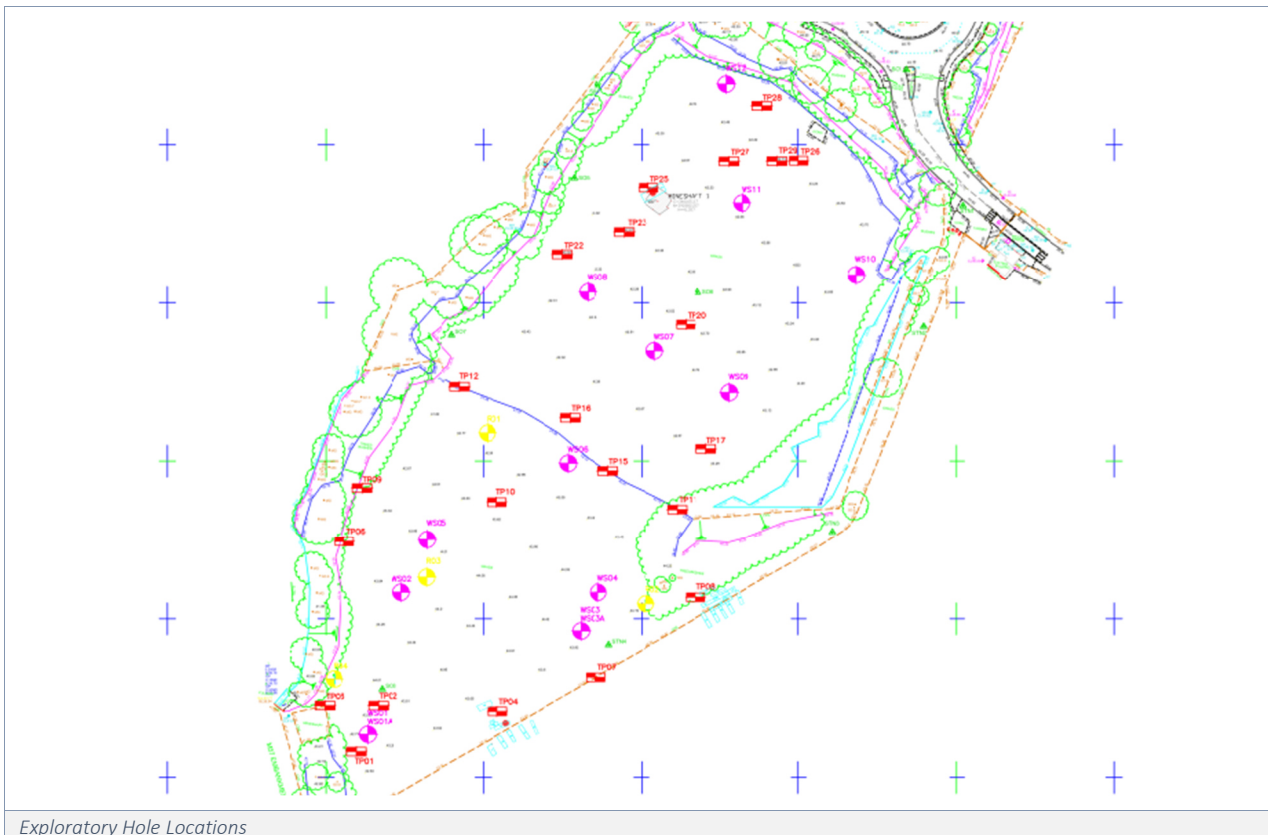
5.0 GROUND MODEL

5.1 Made Ground

Made Ground was encountered beneath the site to a maximum depth of 4.5m bgl. Three main Made Ground populations were encountered during the investigation and are described below:

1. *Brown clayey gravelly fine to coarse sand in TT01 to TT08, TT09, TT12 to TT19, TP01, TP04, TP06 to TP08, TP10 to TP11, TP15 to TP17, TP22, TP23, TP25 to TP29, WS02, WS03, WS03A, WS04 to WS06, WS07 to WS12 to a maximum depth of 4.5m bgl.*
2. *Brown occasionally orange/yellow clayey sandy gravel in TT01, TT03, TT09 to TT12, TT15, TT16, TP01 to TP03, TP06, TP09, TP13, TP17, TP20, TP23, TP25 to TP28, and WS01 to a maximum depth of 4.3m bgl.*
3. *Brown gravelly sandy clay in TP10, TP22, TP27, WS02, WS03, WS05, WS06, WS09 to WS12 to a maximum depth of 3.5m bgl.*

Deep Made Ground was encountered in the north west of the site confirming that the Sewage Disposal Works and associated tanks/beds previously identified is contained within the north west area of the site and not across the whole of the north of the site as shallower Made Ground was encountered within the north east.



Deep Made Ground was also encountered within the south west of the site indicating that the opencast quarry was located within this area. Glass bottles and other evidence of the historic refuse tip were encountered within the northern area of the opencast quarry.

5.2 Natural Ground

The natural strata encountered generally confirmed the published geological records. Three main natural stratification were encountered during the investigation and are described below:

- *Soft Clay was present in TP07 to TP09, TP29, TT02 and WS11 to depths of between 1.2m and 4.0m bgl.*
- *Firm and stiff Clay was in TT03 to TT09, TT12 to TT16, TT18 to TT20, WS03A, TP01, TP07, TP08, TP11, TP13, TP15, TP20, TP26, TP28 and TP29 to depths of between 3.4m and 5.9m bgl.*
- *Brown gravelly clayey fine to coarse Sand was present in TP02, TP04, TP07, TT07, TT08, TT10 and TT11 to a maximum depth of 5.5m bgl.*

Clay was recorded in R02 to R04 to depths of between 9.2m and 13.3m where bedrock was encountered.

5.3 Bedrock

Bedrock was encountered in R01 to R04 from depths between 4.5m and 13.3m and generally consisted of interbedded Sandstone, Siltstone and Mudstone to 30m bgl where the holes terminated.

A thin seam of Coal was encountered within R03 between 22.5m to 22.55m bgl.

5.4 Groundwater

Groundwater strikes were encountered in the exploratory holes as detailed in the table below.

Location	Depth of Strike (m bgl)	Strata	Type
TP03	2.00	Made Ground	Seepage
TP06	3.90	Made Ground	Seepage
TP07	3.30	Natural Strata (Granular)	Strike
TP09	2.70	Made Ground	Seepage
TP13	2.80	Made Ground	Seepage
TP16	2.10	Made Ground	Seepage
TP17	3.50	Made Ground	Seepage
TP20	3.20	Natural Strata (Cohesive)	Perched
TP22	3.30	Made Ground	Seepage
TP25	2.80	Made Ground	Seepage
TP26	1.40	Made Ground	Seepage
TP27	1.90	Made Ground	Seepage
TP29	1.20	Made Ground	Seepage

No groundwater was encountered in the remaining exploratory holes.

5.5 Watching Brief

A watching brief was maintained during the Ground Investigation for visual and olfactory evidence of contamination.

Olfactory evidence of hydrocarbon contamination was encountered in TP08, TP25, TP28, WS08, and WS09.

Glass, plastic, wood, concrete, brick, ceramics, and metal were encountered within the majority of the Trial Trenches and also in TP06, TP09, TP10 and TP13 indicating evidence of contamination.

Colliery spoil was present in TT10, TT11 TT12, and TT18 which are located around both of the unidentified mine shaft locations, as well as within TP02, WS02, WS03, WS03A, WS05, WS08, and WS09.

No other significant visual or olfactory evidence of potential contamination was noted during the Ground Investigation.

5.6 Excavation/Borehole Stability

No evidence of spalling or collapse was noted during excavation of the trial pits or drilling of the boreholes.

5.7 Excavation/Borehole Progress

Trial pit excavation was slow in TP23 and TT01 due to a concrete obstruction at 1.4m and 1.5m bgl respectively.

The concrete obstruction identified in TT01 was a concrete cap for mine shaft SHAFT346392-008, the dimension were 6.8m x 6.8m x 0.8m.

6.0 COAL MINING RISK ASSESSMENT (CMRA)

6.1 Introduction

A Desk Study has previously been undertaken for the site by e3p which has identified a risk from recorded shallow workings and mine entries on site. No evidence of workings, coal seams or unrecorded mine entries were encountered by the Ground Investigation undertaken by e3p. Further investigations have been undertaken by Groundtech Consulting. This Coal Mining Risk Assessment will summarise the findings of the investigation and make recommendations for any ground treatment required.

6.2 Coal Authority Permissions

Permission to carry out intrusive works at the subject site were sought from the Coal Authority prior to the investigation taking place. The permit was granted on 5th April 2023 (Ref: 26317) and Intrusive site investigation works undertaken between the dates of the 6th June and 9th June 2023.

6.3 Coal Authority Consultation

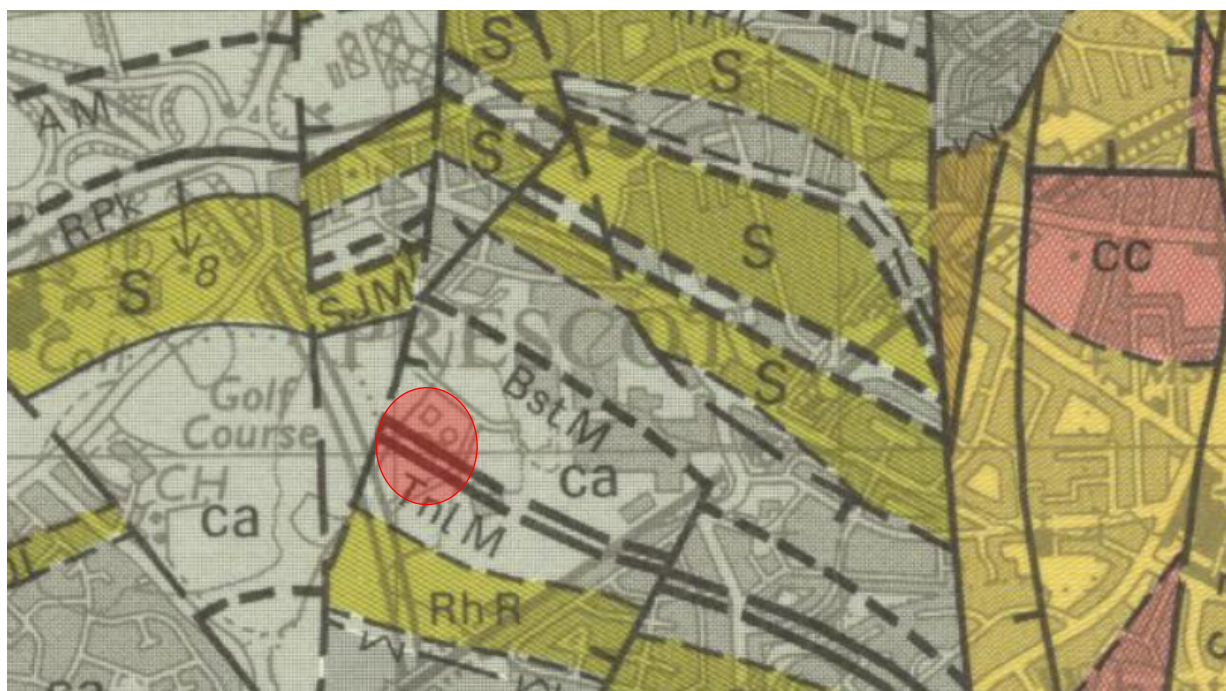
The site lies in an area where the Law Society and Coal Authority recommends a mining consultation is undertaken due to past or current mining possible affecting the site. A Consultants Coal Mining Report was commissioned from the Coal Authority by e3p.

Past Mining

The site is in a surface area that is underlain by recorded coal mine workings at depth in the Rushy Park Mine.

The coal seams identified beneath the site are presented in the table below.

Seam	Est depth beneath bedrock surface	Dip of Seam (°)	Extraction Thickness (m)	Year last mined
<i>Tenlands</i>	<i>Surface</i>	<i>6-8</i>	<i>-</i>	<i>-</i>
<i>Bastions</i>	<i>7.2m</i>	<i>6</i>	<i>1.2</i>	<i>-</i>
<i>Rushy Park</i>	<i>c.147m</i>	<i>8</i>	<i>0.9</i>	<i>-</i>



Geological Sheet Map

Present Mining

The site is not within the zone of influence of any present active underground coal workings.

Future Mining

The property is not in an area where the Coal Authority are determining whether to grant a licence to remove coal by underground workings.

The property is not in an area likely to be affected at the surface by any planned underground workings.

No notice of the risk of land being affected by subsidence has been given under section 46 of the Coal Mining Subsidence Act 1991.

Mine Entries

There are 17 mine entries on or within 20m of the site boundary, 4 are located on the site as detailed below:

Type	Reference	Location	Treatment	Mineral
Shaft	346392-001	-	Unknown fill and concrete capped at surface level.	Coal
Shaft	346392-008	-	Unknown fill and concrete cap at 1.4m bgl.	Coal
Shaft	346391-015	-	Not found	Coal
Shaft	346391-016	-	Not Found	Coal

Coal Mining Geology

The Authority is not aware of any damage arising to geological faults or lines of weakness that have been affected by coal mining. No faults, fissures or breaklines recorded.

Opencast Coal Mining

A historic unlicensed opencast quarry known as Old Carr Pit was situated in the south of the site where coal has been removed by opencast methods.

Mine Gas

There is no record of mine gas emission requiring action by the Coal Authority within 500m of the boundary of the property.

Mine Water Treatment Schemes

None recorded within 500 metres of the enquiry boundary.

Withdrawal of Support

The property is not in an area which notice of entitlement to withdraw support has been published.

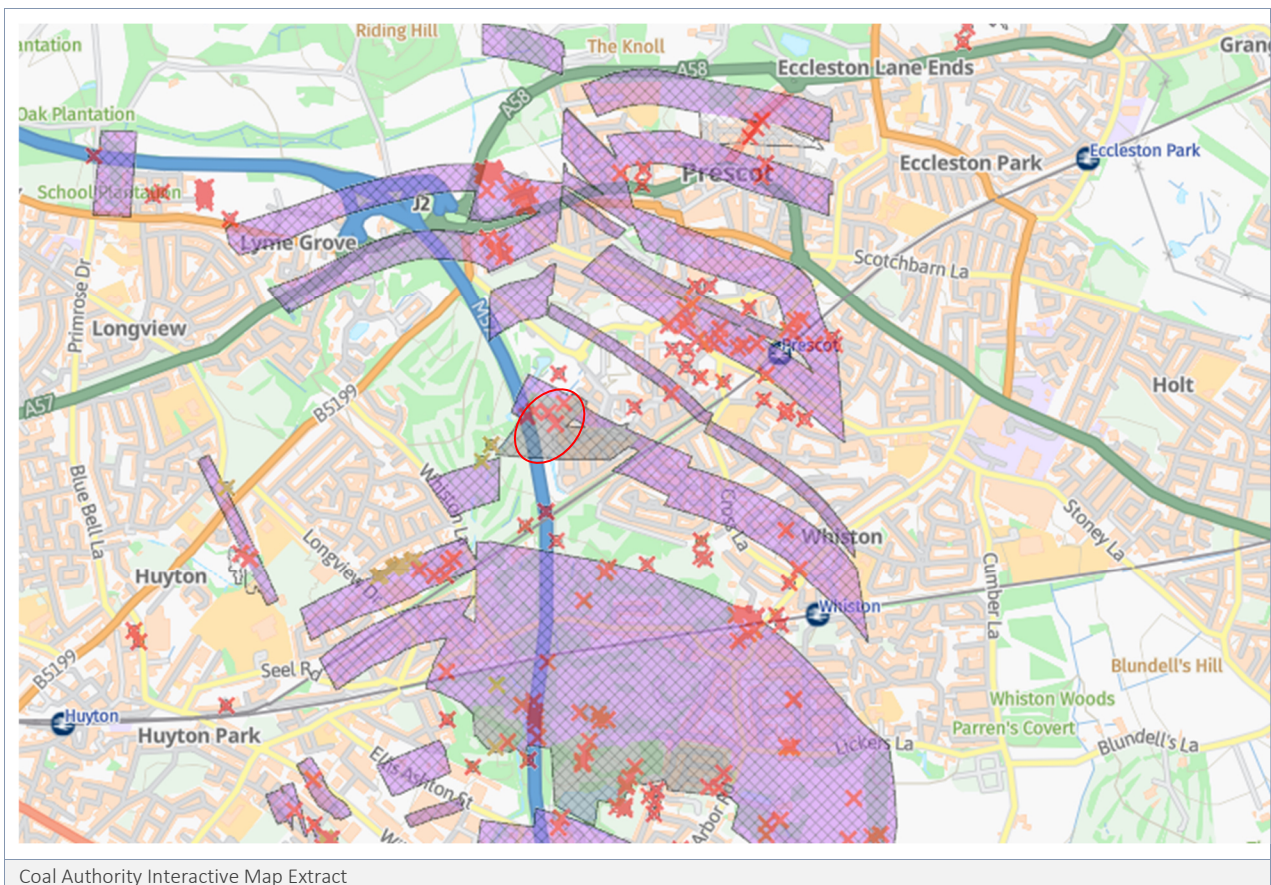
Additional Mineral Workings/Extractions

No additional workings are located within the site.

Coal Authority Interactive Map

The online Coal Authority interactive map has been inspected and the following information has been obtained:

- *The majority of the south of the site and parts of the north of the site are in a Development High Risk Area.*
- *Probable shallow workings are indicated to underlie in the south of the site.*
- *There are four mine entries on the site and surrounding area.*
- *Coal outcrops are indicated in the centre of the site and to the north east of the site.*
- *Surfacing mining was undertaken in the south of the site.*



6.4 Abandonment Plans

No Abandonment Plans were available from the Coal Authority.

6.5 Coal Mining and Geological History

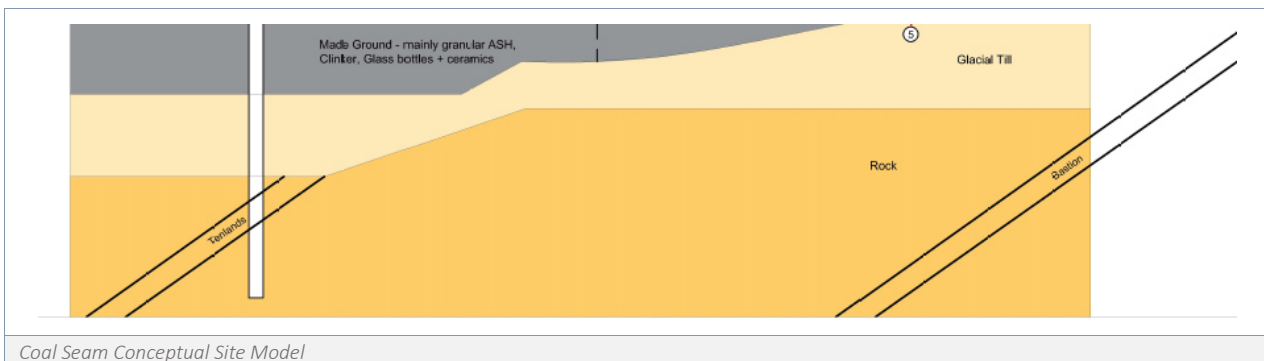
The site is underlain by Mudstone, Siltstone and Sandstone bedrock with Coal seams that represent the Pennine Lower Coal Measures. Clay and gravelly clayey Sand was encountered as superficial deposits.

Geological maps indicate the bedrock in the area dips 8° to the south.

6.6 Coal Seams Identified by the Investigation

Coal was only present within RO3 at 22.5m bgl and was 0.05m thick, this is not considered to be part of an identified coal seam but rather an unnamed, inferior coal seam.

An extract showing the approximate positions of the coal seams are provided below.



A coal mining features plan is provided in *GRO-22463-P07*.

6.7 Mine Entries Identified by the Investigation

The first phase of Ground Investigation conducted between 6th June to 9th June 2023 included exploratory boreholes positioned over the Coal Authority's coordinates for the mine shaft entries on site. The shaft in the south of the site, SHAFT346392-008, was already located identified by a concrete cap and pyramid, with fencing surrounding. TP03 was excavated to the side of SHAFT346392-008 to identify the thickness and strata below the concrete cap. The dimensions of the cap were 6.8 x 6.8m and 0.7m thick. Made Ground was identified beneath the cap comprising sandy gravel. No further evidence of the remaining three mine shaft entries was identified within TP04, TP08 and TP25. Therefore, further Ground Investigation recommended.

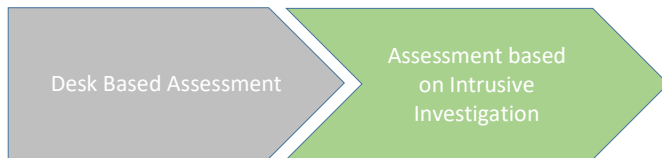
Further Ground Investigation was undertaken between 10th July and 12th July 2023 comprising 20 No. Trial Trenches to attempt to and locate the recorded mine shafts. This took place to allow progression of the final development layout design.

A concrete cap was encountered on the location of SHAFT346392-001 in the north of the site on 10th July 2023 whilst excavating TT01. The top of the cap was at 1.4m bgl and the dimensions were 6.8m x 6.8m and was 0.8m in thickness. These are similar dimensions to the mine shaft SHAFT346392-008 already visible in the south of the site.

SHAFT346391-015 and SHAFT346391-016 are recorded along the eastern site boundary and anecdotal evidence suggests one of them was encountered during the construction of the noise bund along this boundary, trial trenches (TT02 to TT20) were excavated in th and in the surrounding areas and no evidence of the concrete caps were observed. This included excavating into the boundary noise bund. No evidence of the mine shaft caps was identified, however colliery spoil was identified within TT10, TT11 TT12, and TT18 and therefore is likely to be located below the noise bund.

Further trial trenching was not undertaken to the west of the two mine shafts not located as several constraints limited excavation. Several stands of Japanese Knotweed surrounded the area of SHAFT346391-015, as well as numerous mature and semi-mature trees with ecological restrictions. The area surrounding SHAFT346391-016 also contained several semi-mature and mature trees as well as a very large section of concrete pipe. Therefore, a watching brief should be maintained during enabling works and ground works within this area. If any voids or areas of deep Made Ground are identified, work in that area should cease and Groundtech Consulting should be contacted for further guidance and recommendations.

The Coal Mining Risk Assessment presented on the following pages has been compiled to assess the risks associated with historic coal mining based on the information obtained from all sources.



- The table below represents the second stage in the risk assessment process based on an **Intrusive Investigation**.
- In order for a development site to be deemed 'suitable' the level of risk needs to be reduced to an acceptable level. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence that the surface of the site is stable for development.

Coal Mining Risk Assessment for a residential development at Carr Lane, Prescott				
Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
Recorded Coal Workings	○ Ground subsidence. ○ Ground instability.	No – The site is not in an area where Past Workings are indicated at shallow depths. The Coal Authority states that the shallowest workings are 147m bgl and all movement associated with the historic workings will now have ceased.	Not Applicable	No Action Required
Recorded Mine Entries	○ Catastrophic collapse of mine entry leading to ground instability or voids at the ground surface. ○ Settlement of the ground surface above/adjacent to the mine entry. ○ Generation of crown holes at the ground surface. ○ Mines gas emissions.	Yes – Four recorded mine shaft entries are present on the site, 3 within the southern area and 1 within the northern area. The depth of the shafts are unknown as no abandonment plans are available. SHAFT346392-008 had already been identified by a concrete cap and pyramid, at surface level, in the far south of the site prior to the commencement of the Ground Investigation. SHAFT346392-001 in the north of the site was identified through Trial Trenching. The top of the cap was at 1.4m bgl and the	Ground subsidence associated with mine shafts can give rise to levels of damage to the built environment that may affect both serviceability and design life of a structure. Furthermore, mine shaft entries give a direct pathway for mine gas emissions to migrate to the surface of the site.	The mine shafts that have been located have already been capped at surface level (SHAFT346392-008) and at 1.4m bgl (SHAFT346392-001) using a similar sized cap, 6.8 x 6.8m and 0.8 m thick. No further remedial action is considered necessary with regards to SHAFT-008 which is capped, marked at the surface and fenced off – this shaft is located in an area of proposed Public Open Space. SHAFT-001 was located on the northern area of the site and is capped at 1.4m bgl. This shaft requires further investigation to determine the

Coal Mining Risk Assessment for a residential development at Carr Lane, Prescott

Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
		<i>dimensions were 6.8m x 6.8m and was 0.8m in thickness. These are similar dimensions to the mine shaft SHAFT346392-008 already visible in the south of the site.</i> <i>SHAFT346391-015 and SHAFT346391-016 along the eastern boundary of the site have not been encountered. Trial trenches were excavated at the anticipated position of the mineshafts and in the surrounding areas (including into the boundary noise bund). However, no evidence of the mine shafts were identified and therefore are likely to be underneath the noise bund/offsite.</i>		<i>depth of the shaft and the surrounding depth to bedrock. This will determine the No Build Zone which will potentially affect the development layout. The shaft will also likely require grouting in accordance with CIRIA C758 and a plug formed due to the anticipated depth of the bedrock.</i> <i>The mine shafts along the eastern boundary of the site are indicated to be offsite and do not affect the development layout. A watching brief should be maintained during the enabling works and groundworks on the eastern extent of the site.</i>
Unrecorded Coal Workings	- o Ground subsidence. - o Ground instability.	Yes – Unrecorded coal workings are indicated beneath the site, however have not been identified during the intrusive investigation at the site as there was no loss of flush or voids within the rotary boreholes. <i>The absence of workings and coal seams is considered to be due to the opencast associated with Old Carrs Pit recorded on</i>	<i>Ground subsidence associated with historic mine workings can give rise to levels of damage to the built environment that may affect both serviceability and design life of a structure.</i>	<i>Further Investigation is required beneath the northern area of the site due to the presence of the mine shaft. The Bastian Coal was not present in e3p investigation in the northern section of site, however Mudstone with coal traces was encountered at approximately the correct depth.</i> <i>The Old Carrs Pit appears to have removed the Tenlands Coal by opencast methods. Some</i>

Coal Mining Risk Assessment for a residential development at Carr Lane, Prescot

Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
		<i>the southern area of the site which has removed the Ravenhead Higher Delf Tenlands and Ravenhead Main Delf Coal.</i> <i>An unnamed coal seam was encountered in RO3 at a depth of 22.5m bgl with a thickness of 0.05m. Due to the minimal thickness of coal it is not considered to be an identified coal seam such as Bastions or Tenlands.</i> <i>The Bastions Coal subcrops approximately 70m north east of site and is anticipated at a depth of 7.2m beneath top of bedrock. Geological memoirs indicate the thickness of the coal to be circa 1.2m.</i>		<i>confirmatory holes should be drilled at the same time as the investigation on the northern part of the site to improve confidence that the risk is low and to prevent the requirement to drill on a plot specific basis.</i> <i>The presence of workings will influence the deep foundation solutions that are selected.</i>
Unrecorded Mine Entries	○ Catastrophic collapse of mine entry leading to ground instability or voids at the ground surface. ○ Settlement of the ground surface above/adjacent to the mine entry.	No – No unrecorded Mine Entries were located across the site. No unrecorded workings have been encountered to date which reduces the risk of un recorded mine entries being present. The shallow coal has been extracted by opencast on the southern	Ground subsidence associated with historic unrecorded mine entries such bell pits can form crown holes and localised instability that give rise to levels of damage to the built environment that may affect both serviceability and design life of a structure. The is dependent on the treatment of the mine entry.	The Ground Investigation did not record any indication of unrecorded mine entries across the site. If any voids, areas of deep Made Ground or features indicative of a mine entry are identified during the enabling or ground works - work in that area should cease and

Coal Mining Risk Assessment for a residential development at Carr Lane, Prescott

Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
	- Generation of crown holes at the ground surface. - Mines gas emissions.	area of the site and unrecorded mine entries prior to this would have been removed at the same time.	Ground subsidence associated with mine shafts can give rise to levels of damage to the built environment that may affect both serviceability and design life of a structure. Furthermore, mine shaft entries give a direct pathway for mine gas emissions to migrate to the surface of the site.	Groundtech Consulting should be contacted for further guidance and recommendations.
Coal Mining Geology (fissures)	- Ground subsidence. - Mixtures of noxious of explosive gases reaching the ground surface via faulted/broken strata and entering buildings, structures, confined spaces etc., when an explosive or asphyxiating hazard may be generated. - Stepped rockhead profiles where there has been subsidence across faults, impacting settlement. Of proposed structures.	Yes – A fault is present on the western boundary transecting north east to south west, however there is only considered to be a risk if the fault is reactivated due to extensive mining. There is not considered to be sufficient mining activity for this to be considered a risk however, depending on the depth of mineshafts, longwall mining may have occurred.	Movement due to reactivation of the fault can give rise to levels of damage to the built environment that may affect both serviceability and design life of a structure.	Houses within 25m of the position of the fault should be reinforced.

Coal Mining Risk Assessment for a residential development at Carr Lane, Prescott

Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
Records of mine gas emissions	Mixtures of noxious of explosive gases reaching the ground surface via superficial deposits, faulted/broken strata or poorly filled mine entries and entering structures, confined spaces etc., when an explosive or asphyxiating hazard may be generated.	Yes – Located mine shafts SHAFT346392-001 and SHAFT346392-00 and undiscovered mine shafts SHAFT346391-015 and SHAFT346391-016 could be a pathway for mine gas if they have not been backfilled or treated. Ground gas has been recorded at the site however is considered to be associated with the former refused tip and opencast backfill rather than mine gas emissions. No concentrations of mine gases such as methane or hydrogen sulphide have been recorded.	Mine gases could disperse into proposed buildings in close proximity of the mine shaft locations and open cast quarry.	On completion of the ground gas monitoring and assessment, the contribution of the mine shafts to the gas regime on the site will be discussed. The mine shaft on the northern area will be drilled and grouted which will remove the pathway. The shaft along the southern area is outside the development area, monitoring will determine if this a likely source of ga and a risk to the developments. The other two mine shafts are offsite and unlikely to be impacting the development – the monitoring will also assess the risk from these features.
Recorded coal mining surface hazard. Surface mining (opencast workings)	- Ground subsidence. - Ground instability. - Potential of a ground gas source and/or migration pathway. Potential settlement problems. - Combustible material left behind after historic opencast workings may ignite if in the vicinity of excessive heat such as utility cables.	Yes – The Old Carrs Pit opencast mine is located on the south of the site. Deep Made Ground within this area confirms the location to be south west/west. However, No evidence of the quarry high wall was encountered throughout the investigation. No areas of No Build due to the high wall have been discovered. The opencast is also later recorded as a refuse heap, the opencast is a source of ground gas and potentially combustible	Ground gases may be generated by the fill material within the historic opencast mine which could potentially migrate into proposed buildings in the vicinity of the former opencast mine. Due to the loose and variable nature of the fill material significant settlement is likely if traditional foundations are founded in the reworked soils in this area.	Ground gas monitoring is ongoing to quantify the risk from gases potentially generated by the fill material. A larger dataset is required to accurately characterise the site as a number of sources are present. Proposed buildings situated within the former opencast mine require deepening to suitable founding strata to satisfy ULS and SLS conditions. Combustibility testing should be undertaken.



Coal Mining Risk Assessment for a residential development at Carr Lane, Prescott				
Issue	Hazard	Site Affected	Consequence	Recommended Mitigation Measures
		<i>material. Further investigation is required including bomb calorific testing.</i>	<i>Potentially combustible colliery spoil is present at the position of the opencast and an ignition source could cause combustion.</i>	

7.0 GROUND ENGINEERING

7.1 Geotechnical Testing Results

Comparison of water content and the value of 0.4 times the Liquid Limit in accordance with BRE Digest 412 'Desiccation in Clay Soils' suggests significant desiccation has taken place when 0.4 times the Liquid Limit is greater than the actual water measured water content. This is a rudimentary method but also a good guide.

Results of the plasticity testing and the volume change potential of the Clay is summarised in the table below:

Reference	Depth (m bgl)	Modified PI	Volume Change Potential	Significantly Desiccated
TP07	1.50	12.2	Low	N
WS03A	1.30	17.3	Low	N
TP09	2.95	130.34	Extremely High	N
TP11	1.00	18.2	Low	Y
TP13	3.00	10.5	Low	N
TP15	2.50	10.9	Low	Y
TP26	3.50	13.3	Low	N
TP29	2.00	11.2	Low	N

The plasticity index result from TP09 at 2.95m bgl is not considered to be representative for the site and likely to be associated with the localised organic content of this sample.

The results of the Quick Undrained Triaxial test are summarised below:

Reference	Depth (m bgl)	Shear Strength (kPa)	Strength Classification
WS11	2.50 - 3.00	46	Medium

7.2 Assessment Background

Background

The ground engineering investigation has been undertaken to formulate an accurate ground model in order to undertake preliminary foundation design. The ground model has been constructed with a moderate to high level of confidence.

History

Historical mapping suggests that the southern area of the site is the former location of Old Carrs Pit and associated pumping station, plans of this mark a shaft to the southern end of the site. Between the 1960s and 1990s, the south was used as a refuse tip.

From the early 1920s, the northern area of the site formed part of Prescott Sewage Disposal Works and featured sludge beds, storm tanks, screen chambers, settling tanks, filter beds, pumps and humus tanks. From the 1950s, a number of drains are marked through the sewage disposal works with the hardstanding area no longer marked. Embankments are present surrounding the works and along the western boundary. By the late 1990s, the works buildings are no longer present.

Prescot Brook runs along the western boundary of the site and the area itself is marked with sporadic trees and rough pasture throughout. A public footpath runs along the eastern boundary of the site.

Proposed Development

The proposed development is residential end use comprising the construction of residential dwellings with soft landscaped gardens and associated hardsurfaced driveways and roads. Loadings associated with the proposed structures are unknown at this stage and recommendations are based on existing site levels.

Ground Conditions

Made Ground was encountered to a maximum depth of 4.5m bgl and consisted mainly of clayey gravelly sand, clayey sandy gravel and gravelly sandy clay. The Made Ground was underlain by generally firm and stiff sandy gravelly Clay, and gravelly clayey Sand to depths of between 4.5m and 13.3m bgl. Soft Clay was present in TP07 to TP09, TP29, TT02 and WS11 to depths of between 1.2m and 4.0m bgl which is shown on Groundtech plan *GRO-22463-P08*.

Bedrock was encountered from depths of between 4.5m and 13.3m bgl and consisted of interbedded sandstone, siltstone and mudstone to depths of up to 30m bgl where the holes terminated. A thin seam of Coal was encountered within R03 between 22.50 to 22.55m bgl.

Groundwater was encountered at depths of between 1.2m and 3.9m bgl within the Made Ground and natural strata.

Limitations

The main limitation for the development is the mine shafts recorded on the site, the location of the two eastern mine shaft entries (SHAFT346391-015 and SHAFT346391-016) have not been confirmed, they are most likely underneath the noise bund on the eastern border of the site. Twenty Trial Trenches were excavated to attempt to locate the mine shaft entries, only the northern mine shaft entry (SHAFT346392-001) and the southern mine shaft (SHAFT346391-016) are known.

Japanese Knotweed is present on the site which will need to be treated or removed prior to construction commencing.

Historically, buildings including an extensive Sewage Disposal Works were present on site and former foundations and obstructions should be grubbed up as part of the enabling works. The concrete obstructions should be processed and all material placed as engineered fill. Deep Made Ground may cause limitations to construction of the new residential buildings. Deep Made Ground and soft Clay have been encountered to depths of up to 4.5m bgl.

Open cast mining was undertaken in the southern area of the site historically and a number of mineshafts are located around the perimeter of the southern area of the site. A single mineshaft is indicated to be present within the northern area of the site.

7.3 Geotechnical Parameters

The geotechnical test results have been evaluated to derive geotechnical parameters for the soils underlying the site. A 'Depth to SPT N value' graph is presented on Plan *GRO-22463-P04* in *Appendix 7* to provide a generalised ground model for the site.

Characterisation of the geotechnical parameters above has been undertaken to select a characteristic value, which is a cautious estimate of the value affecting the occurrence of the limit state. The characteristic values for the Ultimate Limit State (ULS) conditions selected are presented in the table below:

Stratum	Parameter	Selected Characteristic Value
Soft Clay	Undrained Shear Strength (C_u)	25kPa
Medium Strength	Undrained Shear Strength (C_u)	46kPa
Very Loose Sand	Drained angle of friction (ϕ')	28°
Medium Dense Sand	Drained angle of friction (ϕ')	33°
Very Dense Sand	Drained angle of friction (ϕ')	42°
Siltstone / Sandstone	Drained angle of friction (ϕ')	34°
Mudstone	Undrained Shear Strength (C_u)	200kPa

7.4 Preliminary Foundation Design

Deep Made Ground has been encountered across the site to a maximum depth of 4.5m bgl which is underlain mainly by natural soft to firm medium strength Clay and very loose to very dense sand. Bedrock has been encountered from depths of between 4.5m and 13.3m bgl. Based on the ground conditions encountered, traditional shallow foundations are not considered suitable for the proposed development.

7.4.1 Foundation Recommendations for the Southern Area

The site has been separated into two areas, the northern area and the southern area. The extents of these areas can be seen on Groundtech plan GRO-22463-P08.

Vibro Stone Columns (VSCs)

As discussed above, the Made Ground should be turned over to remove all obstructions.

The most suitable solution for the proposed development in the southern area is considered to be Vibro-Stone Column (VSCs) to a partial depth with a reinforced raft foundation above. The Made Ground is too deep for full depth treatment, therefore the raft foundation should be adopted.

Preliminary discussions with a vibro contractor have indicated that ground improvement with VSCs will be a viable option for the proposed development. The contractor has noted the presence of asbestos within the Made Ground soils and recommend that a suitable specialist contractor is appointed to minimise any potential health risks during the ground improvement works.

There are SPT N values of 0 recorded within the southern area of the site, therefore the vibro contractor has requested the opportunity to view trial pits in these areas to try and understand the reason for the low values. Some soft Clay with shear strengths of less than 30kPa are also present which they would like the opportunity to inspect. The ground conditions may determine that Controlled Modulus Columns (CMCs) are required as opposed to VSCs.

A preliminary design resistance for ultimate limit state and serviceability limit state conditions will be provided by the specialist vibro contractor in their detailed design. The specialist contractor should provide fitness for purpose cover for the treated zones and depth of treatment.

A reinforced raft can then be constructed over the vibro treated ground.

A suitable piling mat will need to be designed and placed to allow the installation of the VSCs.

Alternative Solution - Pile Foundations

Pile foundation may also be a viable option, transferring loads through the Made Ground and natural Clay and Sand deposits to the Mudstone, Sandstone and Siltstone bedrock which has been encountered from depths of between 4.5m and 13.3m bgl. When permanent and variable actions are available, the utilisation factor can be confirmed or otherwise in accordance with EC7.

Driven piles are likely to be the most suitable piling option end bearing in the bedrock. This should be discussed with the preferred piling contractor. Good workmanship will be required when installing the piles to ensure the assumptions in the design by calculation are met. The type of pile and pile material should provide sufficient lateral stability due to the poor ground conditions observed where soft Clay and very loose Sand is present.

Preliminary design by calculation has been carried out using due skill and care using the global factor of safety method for pile design, a global factor of safety of 2.5 has been used. The preliminary design by calculation is based on combined skin friction/end bearing piles in the Clay. The preliminary design by calculation is based on the following ground model:

- *Made Ground to 4.5m bgl.*
- *Medium strength Clay to 13.3m bgl*
- *Mudstone bedrock*

For a single square 225mm diameter pile 14m in length, a vertical allowable load of 200kN has been calculated. The vertical allowable load would be reduced to 80kN for a 5m pile where the bedrock is shallower. Where Sandstone is the end bearing strata, the allowable load will increase to in excess of 300kN. This emphasises the importance of the piles being driven to sett using pile driving formulae and the design can be efficiently revised.

If greater loads are required, the diameter of the piles should be increased and/or the piles installed in groups. This should be considered when the loadings are confirmed. If steel piles are being used, the diameter is likely to be reduced to 178mm and this should be allowed for in the detailed design.

To date, workings have not been encountered, if a potential risk from workings is identified, pile foundations will not be feasible unless drilled through treated workings and approved by the Coal Authority.

The ground conditions and the below ground construction indicate that downdrag may be an issue as very loose Sand and soft Clay has been encountered and should be considered in the detailed foundation design.

An appropriate working platform should be constructed in accordance with BR470 guidance.

The piling type, length, depth of reinforcement and design should be discussed with a specialist piling contractor, it should also be discussed if CFA piles would be more cost beneficial. They can then undertake the detailed design including drawings and specifications to provide fitness for purpose design.

Static load testing is recommended by EC7 to validate the design, this is unlikely to be cost beneficial and a suitable factor of safety should be adopted instead subject to approval from the warranty provider. The piling works should be carried out in accordance with Execution Standard EN 1536 for Bored Piles or BS EN 12699:2015 'Execution of special geotechnical works. Displacement piles'. The piles should be driven to sett using pile driving formulae.

7.4.2 Foundation Recommendations for the Northern Area

The most suitable foundation solution for the northern area is considered to be reinforced strip foundations on Vibro Stone Columns (VSCs). This solution will be constructed after the enabling and earthworks exercise have been completed. The top 2m to 3m of Made Ground require excavating, processing and placing to an end product/performance specification.

On completion of the earthworks, the VSCs should be installed and the reinforced foundations cast spanning between columns. The depth of foundations is to be between 0.35m and 0.6m below the surface of the vibro treated ground as the integrity of the columns is not validated to this depth. The reinforced concrete foundation should be designed by the structural engineer to span between the centres of adjacent stone columns.

The recommendations above for the southern area are also applicable for the northern area, with the exception of the requirement for a raft, because full depth treatment will be achieved beneath the northern area.

Founding in the Made Ground in its present condition is not a viable solution due to its heterogenous composition and compaction. Likely relict foundations were encountered in TP22, TP23, TP27, TP28, and TP29.

The extents of this soft clay and also obstructions encountered that will likely affect the proposed foundations at the site can be seen on Groundtech plan *GRO-22463-P08*.

All fill should be placed in layers in accordance with The Specification for Highways Work Series 600. For each layer, testing should be carried out to confirm the properties of the filled soils including whether the specified Maximum Dry Density has been achieved. During the construction of the fill, the suitability/acceptability testing shall be undertaken at a suitable frequency of fill or when the source of the fill changes. The testing requirements will be outlined in the earthworks specification. The end product should meet the criteria of 95% Maximum Dry Density (MDD) and less than 5% air voids for upfill material.

Locally trench fill foundations may be viable, this will be determined after the enabling works when an As Built Survey is available and a plot specific foundation schedule have been produced.

Construction Requirements

The recommendations in this appraisal are preliminary, the detailed design should be developed in advance and during the construction phase. If the ground conditions or groundwater regime encountered during the construction phase differ significantly to the conditions encountered during the Ground Investigation, work should cease and Groundtech Consulting contacted for further advice.

During the construction phase, supervision by a suitably qualified geotechnical engineer should be on a continuous basis to check the design assumptions are correct and construction conforms to design in accordance with EC7. Supervision should include inspections, Control Ground Investigations and monitoring by a suitably qualified geotechnical engineer.

7.5 Floor Slabs

Made Ground in excess of 600mm has been encountered beneath the site and suspended floor slabs will be required where pile foundations are utilised. There may also be a requirement for a suspended floor slab if passive ventilation for gas precautions is installed.

Ground bearing floor slabs will be adopted for VSCs, and the floor slab will be integrated into the raft foundation on the southern area of the site.

If any of the plots are affected by heave, the void dimension under ground beams and suspended in-situ concrete floors should be 50mm, and beneath suspended precast concrete floors is 200mm.

7.6 Building Near Trees

Foundation excavations may encounter shallow Clay deposits. Trees have been identified on site therefore foundations should be designed in accordance with NHBC Standards Chapter 4.2.

All foundations should be deepened below roots of greater than 5mm diameter during excavations for footings. The clay beneath the site is of a *Low* volume change potential.

A survey of all trees and hedges on the site and within 30m of the site boundary should be undertaken to identify tree species, locations and heights. This information will be required in order to assess the effects of trees on the cohesive strata and inform a foundation schedule.

Where foundation depths due to trees already present or recently removed exceeds 1.5m there is a possibility for heave to occur on removal of the tree. NHBC guidance states that in areas where volume change potential is *Low*, a void or void former is not required against the side of foundations and ground beams is not required.

7.7 Construction

The trial pits indicate that instability of excavations is not anticipated provided they are not exposed to adverse weather conditions for any substantial period of time. Instability of the Made Ground is a possibility and should be considered in the groundworks method statements.

Groundwater has been encountered between depths of 1.2m and 3.9m bgl and so dewatering of excavations may be required during the construction of the proposed developments.

Tracked high specification plant is recommended to maintain the build programme. Breaking equipment may also be required locally to penetrate obstructions identified by the Ground Investigation.

7.8 Concrete Classification

Made Ground

Water soluble sulphate testing was undertaken on two samples of the Made Ground. The range of soluble sulphate (SO₄) recorded is 183.4mg/l to 734.4mg/l and associated pH values ranged between 5.94 and 6.47 indicating slightly acidic conditions.

The characteristic water soluble sulphate concentration is 734.4mg/l and the pH value is 5.94.

Natural Strata

Water soluble sulphate testing was also undertaken on five samples of the natural strata. The range of soluble sulphate (SO₄) recorded is 29.4mg/l to 71.4mg/l and associated pH values ranged between 6.65 and 8.76 indicating slightly acidic to slightly alkaline conditions.

For a dataset of between five and nine results, the characteristic water soluble value is taken as the average of the highest two results and the characteristic pH value is the average of the lowest two values. Therefore, the characteristic water-soluble sulphate concentration is 64.3mg/l and the pH value is 6.98.

Granular strata are present beneath the site therefore, the groundwater is considered to be mobile.

The results of laboratory pH and sulphate content indicate that for concrete in contact with natural strata ACEC Class AC-3z and sulphate class DS-2 conditions prevail in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005. The specific concrete mixes (the Design Concrete Class) to be used on site will be determined by the site-specific concrete requirements in terms of the durability and structural performance. These are assessed in terms of the Structural Performance Level (SPL) and any need for Additional Protective Measures (APM) detailed in Part D of BRE Special Digest 1 with further guidance in Pt E and F.

Potential for Pyritic Ground

Additional testing was undertaken to determine if the soils underlying the site are potentially pyritic. Two samples of Made Ground and five samples of natural ground were tested for total sulphur and total sulphate which was used to determine the total amount of oxidisable sulphides in the sample. If the amount of oxidisable sulphates is greater than 0.3% SO₄, pyrite is probably present.

The total amount of oxidisable sulphates in the samples was determined to be between 0.02% and 1.95% and was greater than 0.3% SO₄ in three of the samples which include the Made Ground in TP02 and WS08 and the natural Clay of TP29. The underlying soils are therefore considered to be potentially pyritic.

Total Potential Sulphate (TPS) values of between 0.03 and 2.22% SO₄ have been determined and taking the characteristic value as being the average of the highest two values, this equates to 1.56% SO₄. Using Table C2 of BRE Special Digest 1 "Concrete in aggressive ground" 2005, the soils are classified as being ACEC Class **AC-4** and sulphate class **DS-4**.

The soils beneath the site are potentially pyritic and therefore the concrete classification is ACEC Class AC-4 and sulphate class DS-4 which may make the use of concrete piles uneconomical. In addition, contaminated soils are present beneath the site which have been classified as being hazardous therefore, bored piles are unlikely to be an economical option due to the need to remove arisings offsite.

7.9 Highway and Pavement Design

CBR values of 2% to 3% are likely to be achieved in undisturbed natural cohesive soils for pavement design purposes, unless proven otherwise by in-situ testing at sub-base level by a specialist geotechnical engineer. As a minimum, the subgrade should be proof rolled prior to construction. Some reengineering of the subgrade is required prior to highway construction to achieve the required design CBR value.

Untreated Made Ground should be assumed to have a CBR value of less than 2.5%, unless proven otherwise. Highways Agency document HD25 'Interim Advice Note 73/06 Revision 1' (2009) states that where a subgrade has a CBR value lower than 2.5%, it is considered unsuitable support for a pavement foundation since it would tend to deform under construction traffic and must be improved.

Where highways are proposed in areas underlain by Made Ground, it is recommended that Made Ground to a depth of 1.0m below subgrade level is excavated, sorted and classified in accordance with Series 600 (Earthworks) of the Highways Agency "Specification for Highways Works". Following the above, any suitable



material which can be used as part of highway construction shall be compacted in accordance with the earthworks specification. This can be undertaken as part of the enabling works.

The soils are considered to be frost susceptible due to the fines content and highway/pavement construction should be a minimum thickness of 450mm to mitigate the risk.

7.10 Sustainable Urban Drainage System (SuDS)

The use of SuDS drainage is not considered to be a feasible option as the site is predominantly underlain by deep Made Ground which is contaminated and natural cohesive ground.

7.11 Embankments/Noise Bunds

The noise bunds appear to be stable from visual inspection, it is recommended the construction details are obtained from the adjacent developer and a watching brief is maintained during the enabling works and groundworks regularly for signs of instability. No over excavation should be undertaken at the toe of the bund.

8.0 LAND QUALITY

8.1 Geo-Environmental Testing Results - Soils

Samples of Made Ground have been tested for a range of relevant Contaminants of Concern. In accordance with LCRM, a Generic Quantitative Risk Assessment (GQRA) has been undertaken to determine the significance of the concentrations as derived through Geo-Environmental analysis.

The GQRA process comprises the comparison of the actual concentrations measured on site with Generic Assessment Criteria (GACs) for the protection of human health.

The GACs used for the assessment of soil concentrations have been derived using the CLEA model. The GACs used are listed below:

- *Soil Guideline Values (SGVs) which demonstrate minimal risk.*
- *LQM/CIEH S4ULs which use the same toxicological data as the SGVs but different exposure criteria.*
- *C4SLs which demonstrate low risk.*

In deriving the GACs for use on Brownfield sites, we have assumed a 1% Soil Organic Matter unless the results indicate otherwise.

The proposed end use of this site is residential development with soft landscaped gardens and associated driveways and road network. We have therefore undertaken the GQRA on the basis that the proposed development site falls under the Residential (with Plant Uptake) land-use scenario as defined in SR3 (EA, 2009b).

The strata or sources of contamination targeted by the laboratory testing scheduled is summarised in the table below:

Strata	Number	Locations
Made Ground	35	TP01 to TP04, TP06 to TP11, TP13, TP15 to TP17, TP20, TP22, TP23, TP25, TP26 to TP29, WS01, WS03, WS03A WS05, WS06 to WS09, WS11, WS12
Natural Strata	1	TP29

A summary of the Geo-Environmental Testing results is presented below and the GQRA screening values are presented in *Appendix 8*:

Contaminant	Range (mg/kg)	Metals		
		Screening Value (mg/kg)	Exceedances	Locations
Arsenic	6.7 – 159.5	37	6	TP08 at 1.00m TP09 at 1.00m TP11 at 0.10m TP13 at 2.00m TP25 at 0.30m TP27 at 1.50m
Boron	0.5 – 20.2	290	0	-
Cadmium	<0.1 – 7.9	10	0	-
Chromium	16.8 – 203.2	910	0	-
Hexavalent Chromium	<0.3	21	0	-
Copper	7-1003	2400	0	-

Lead	10 - 712	200	9	TP04 at 1.00m TP07 at 0.50m TP09 at 1.00m TP10 at 2.50m TP11 at 0.10m TP13 at 2.00m TP20 at 1.00m TP27 at 1.50m WS11 at 0.30m
Mercury	<0.1 – 1.8	1.2	2	TP13 at 2.00m TP20 at 1.00m
Nickel	6.9 – 200.3	130	1	TP13 at 2.00m
Selenium	<1 - 2	350	0	-
Zinc	18 - 1144	3700	0	-
Polycyclic Aromatic Hydrocarbons (PAHs)				
Contaminant	Range (mg/kg)	Screening Value (mg/kg)	Exceedances	Locations
Naphthalene	<0.04 – 0.61	2.3	0	-
Acenaphthylene	<0.03 – 0.56	170	0	-
Acenaphthene	<0.05 – 1.93	210	0	-
Fluorene	<0.04 – 1.33	170	0	-
Phenanthrene	<0.03 – 17.2	95	0	-
Anthracene	<0.04 – 6.09	2400	0	-
Fluoranthene	<0.03 – 23.87	280	0	-
Pyrene	<0.03 – 18.56	620	0	-
Benzo(a)anthracene	<0.06 – 10.40	7.2	2	TP25 at 0.30m WS07 at 0.20m
Chrysene	<0.02 – 9.23	15	0	-
Benzo(b)fluoranthene	<0.05 – 11.82	2.6	4	TP07 at 0.50m TP25 at 0.30m WS07 at 0.20m WS11 at 0.30m
Benzo(k)fluoranthene	<0.02 – 4.60	77	0	-
Benzo(a)pyrene	<0.04 – 10.31	2.2	4	TP07 at 0.50m TP25 at 0.30m WS07 at 0.20m WS11 at 0.30m
Indeno(123cd)pyrene	<0.04 – 5.72	27	0	-
Dibenzo(ah)anthracene	<0.04 – 0.82	0.24	4	TP07 at 0.50m TP25 at 0.30m WS07 at 0.20m WS11 at 0.30m
Benzo(ghi)perylene	<0.04 – 5.85	320	0	-
TPH CWG - Aliphatics				
Contaminant	Range (mg/kg)	Screening Value (mg/kg)	Exceedances	Locations
>C5-C6	<0.1	42	0	-
>C6-C8	<0.1	100	0	-
>C8-C10	<0.1 – 6.9	27	0	-
>C10-C12	<0.2 – 16.8	130	0	-

>C12-C16	<4 - 71	1100	0	-
>C16-C35	<7 - 258	65000	0	-
Total aliphatics C5-35	<19 - 336	-	-	-
TPH CWG - Aromatics				
Contaminant	Range (mg/kg)	Screening Value (mg/kg)	Exceedances	Locations
>C5-EC7	<0.1	70	0	-
>EC7-EC8	<0.1	130	0	-
>EC8-EC10	<0.1 – 0.3	34	0	-
>EC10-EC12	<0.2 – 7.3	74	0	-
>EC12-EC16	<4 – 32	140	0	-
>EC16-EC21	<7 – 84	260	0	-
>EC21-EC35	<7 – 178	1100	0	-
Total aromatics C5-35	<19 – 282	-	-	-
Total aliphatics and aromatics(C5-35)	<38 – 500	-	-	-
MTBE	<0.002	49	0	-
Benzene	<0.003 – 0.012	0.33	0	-
Toluene	<0.003 – 0.018	610	0	-
Ethylbenzene	<0.003	350	0	-
m/p-Xylene	<0.005	240	0	-
o-Xylene	<0.003	250	0	-
Asbestos Screen				
Position	Depth (m bgl)	Result	Asbestos Type	Quantification (mass %)
TP10	2.50	Detected	Chrysotile & Amosite	tbc
TP15	1.00	Detected	Chrysotile & Amosite	tbc
TP17	3.50	Detected	Chrysotile & Amosite	tbc
TP20	1.00	Detected	Chrysotile & Amosite	tbc
TP26	0.20	Detected	Chrysotile & Amosite	tbc
TP27	1.50	Detected	Amosite	tbc
WS08	1.80	Detected	Chrysotile & Amosite	tbc
WS11	0.30	Detected	Chrysotile & Amosite	tbc

The majority of VOCs and SVOCs were recorded at concentrations below the laboratory limits of detection. The following VOCs and SVOCs were above detection limits but below relevant screening values:

- 2-Methylnaphthalene - TP02 at 1.5m, TP04 at 1.0m, TP09 at 1.0m, TP25 at 3.0m, TP28 at 1.8m, WS08 at 1.8m, and WS09 at 2.0m
- Bis(2-ethylhexyl)phthalate - TP25 at 3.0m and WS09 at 2.5m
- Di-n-butyl phthalate - TP02 at 1.5m and TP25 at 3.0m
- Carbazole - TP09 at 1.0m, TP25 at 3.0m, WS08 at 1.8m and WS09 at 2.5m
- Dibenzofuran - TP02 at 1.5m, TP09 at 1.0m, TP25 at 3.0m, TP28 at 1.8m, WS08 at 1.8m and WS09 at 2.5m

• Chloromethane	-	TP04 at 1.0m, TP09 at 1.0m and TP13 at 2.0m
• Trichloroethene	-	TP25 at 3.0m
• 1,3,5 – Trimethylbenzene	-	WS09 at 2.5m
• 1,2,4- Trimethylbenzene	-	WS09 at 2.5m
• Sec-Butylbenzene	-	TP02 at 1.5m
• 4-Isopropyltoluene	-	WS09 at 2.5m
• n-Butylbenzene	-	WS09 at 2.5m

8.2 Generic Quantitative Risk Assessment - Soils

Made Ground was encountered beneath the site to a maximum depth of 4.5m bgl.

Olfactory evidence of hydrocarbon contamination was encountered in TP08, TP25, TP28, WS08, and WS09. Glass, plastic, wood, concrete, brick, ceramics, and metal were encountered within the majority of the Trial Trenches, TP06, TP09, TP10 and TP13. Colliery spoil was present in TT10, TT11 TT12, and TT18 which are located around both of the unidentified mine shaft locations, as well as within TP02, WS02, WS03, WS03A, WS05, WS08, and WS09. No other significant visual or olfactory evidence of potential contamination was noted during the Ground Investigation.

A Contamination Plan is presented as *GRO-22463-P05*.

Metals

Elevated levels of four heavy metals were encountered throughout laboratory testing, the concentrations were predominantly recorded in the northern area of the site and also along the central eastern boundary.

Elevated levels of Lead range between slightly elevated to 5 times the screening level for residential end use, the range of arsenic concentrations was similar to the lead. Mercury and nickel were both slightly elevated. The heavy metal contamination is likely to be associated with the previous sewage disposal works and tanks/filter beds on the northern area of the site, and the colliery spoil along the eastern boundary.

Arsenic, lead, mercury and nickel contamination was identified during the e3p Ground Investigation and showed similar lateral coverage.

Speciated Polycyclic Aromatic Hydrocarbons (PAHs)

Elevated PAHs were recorded in four samples of the Made Ground across the site. These comprised elevated concentrations of Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenzo(ah)anthracene.

The locations of these elevations were similar to the metals being on the northern and central eastern area of the site - therefore the elevations are likely to be from the same source.

Elevated speciated PAHs were recorded during the e3p Ground Investigation in similar areas of the site.

Total Petroleum Hydrocarbons (Aliphatics and Aromatics)

The majority of TPH concentrations were recorded below the laboratory limits of detection. Where hydrocarbons were detected, they were recorded at concentrations below the residential with plant uptake screening values.

VOCs and SVOCs

The majority of the SVOCs and VOCs were recorded at concentrations below the laboratory limits of detection. Where SVOCs and VOCs were recorded, they were at relatively low concentrations and their uses included dyes, pesticides, insecticides, solvents and degreasing agents. They were generally recorded along the western boundary of the site in the general vicinity of the sewage works.

Asbestos

Amosite and Chrysotile asbestos fibres have been detected within the Made Ground in TP10, TP15, TP17, TP20, TP26, TP27, WS08, and WS11. Quantification is currently being undertaken.

Chrysotile and Amosite asbestos fibres were recorded in three locations during the e3p Ground Investigation at concentrations of between <0.001 and 0.288 % mass.

The asbestos was also recorded predominantly in the northern area of the site as shown on the contamination plan.

8.3 Permanent Ground Gases

Eight standpipes were installed for gas monitoring within WS02, WS03, WS05, WS07, WS08, WS09, WS11, and WS12. Three gas monitoring visits have been undertaken between 21st July and 3rd August 2023. Three more visits are scheduled.

No methane has been recorded in any of the standpipes.

Carbon dioxide (CO₂) was detected in all exploratory holes at peak concentrations of between 0.4% v/v and 14.1% v/v. Associated depleted oxygen levels were recorded with concentrations between 0.1% and 21.1% v/v.

A positive gas flow rate of 10.3l/hr was recorded in WS07 during the third monitoring visit, a positive borehole pressure of 1.01mb was also recorded. No other positive gas flow rates or borehole pressures have been encountered.

The monitoring visits was undertaken during periods of steady, falling and rising barometric pressure.

Characterisation of the Gas Screening Value (GSV)

Based on the results recorded to date, in accordance with CIRIA Report C665, the risk to the site from ground gases has been assessed by converting the results to gas screening values (GSVs), calculated by multiplying the typical maximum gas concentrations with the recorded maximum positive flow rates. In addition, individual “hazardous gas flow rates” (Q_{hg}) have been derived for each monitoring point. As no levels of methane have been recorded, a GSV for carbon dioxide only has been calculated.

$$GSV (l/hr) = \text{max borehole flow rate (l/hr)} \times \text{max gas concentration (\%)}$$

For this interim assessment, the maximum recorded concentration of carbon dioxide of 14.1% v/v has been used together with the maximum flow rate of 10.3l/hr for the worst case, the typical case is also summarised below because the individual flow rate is considered anomalous due to the boreholes pressure:

(WORST CASE) Carbon Dioxide GSV = 0.141 (14.1%) x 10.3 = 1.4523 l/hr
(TYPICAL CASE) Carbon Dioxide GSV = 0.141 (14.1%) x 0.1 = 0.0141 l/hr
No hazardous gas flow rate exceed 0.07l/hr

In order to assess the ground gas regime beneath the site and the need to incorporate ground gas precautions, guidance was taken from CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings'. Based on the site being developed for a residential end use with ground bearing floor slabs, the Wilson and Card method has been used to carry out the assessment.

When considering the results in accordance with CIRIA C665 (Section A Development and Table 8.5 – Modified Wilson and Card Classification) it can be seen that the worst case GSV value for carbon dioxide places the site in Characteristic Situation 3. However, the typical case and hazardous gas flow rate place the site in CS1.

Characteristic Situation 1/2

Currently the site has been classified as CS2 based on the typical maximum concentrations of carbon dioxide being 10%v/v, on completion of the gas monitoring programme it is likely a proportion of the site will be reduced to CS1. The site will be zoned but the proportions of the zones will be determined by the final gas assessment.

No concentrations of hydrogen sulphide, methane or carbon monoxide has been recorded indicating the gas concentrations encountered are unlikely to be associated with mine gas from the mine shafts acting as a pathway.

The source of the carbon dioxide is likely associated with the opencast, deep Made Ground and former refuse tip localised in the southern area of the site which generally comprises inert waste and so is not considered a significant source of ground gas, the classification can be potentially be lowered to CS1 and/or allow the site to be zoned.

Methane was recorded in one of the previous e3p locations, slightly lower carbon dioxide concentrations were recorded. The flow rates were highly variable in turn affecting the hazardous gas flow rate significantly.

Radon Gas

The latest radon maps launched by UKHSA indicate the northern part of the site to be in an area where the maximum radon potential is 3% to 5% and basic radon measures may be required within new buildings. It is recommended that a site-specific search is carried out through the BGS to determine the exact level of precautions required.

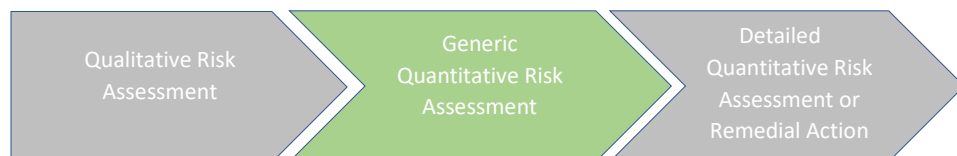
8.4 Revised Pollution Linkage Assessment

A revised pollution linkage assessment has been undertaken based on the findings of the Ground Investigation and testing to identify any realistic pollution linkages in order to quantify the risks to human health and controlled waters. An Illustrative Revised CSM is presented on Plan GRO-22463-P06 and the risk



classification has been estimated in accordance with the CIRIA C552 assessment criteria outlined in *Appendix 9*.

Human Health Pollution Linkage Assessment



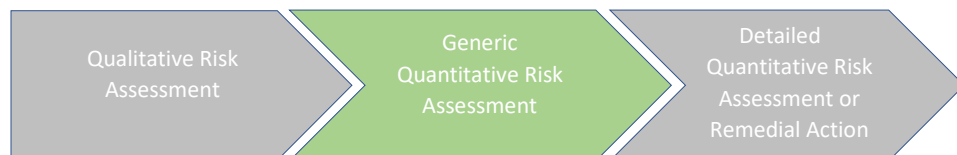
- The table below represents the second stage in the land quality risk assessment process - **the Generic Quantitative Risk Assessment**.
- In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL1	Contaminated Soils	Ingestion of soil and dust. Dermal contact with soil.	Unlikely to Low Likelihood	Medium	Moderate to High	<i>Pollution Linkage 1 refers to proposed site users coming into contact with contaminated soils on the site.</i> <i>Made Ground has been encountered beneath the entire site to depths of up to 4.5m bgl.</i> <i>Elevated concentrations of heavy metals and speciated PAHs are present on site and correlates with the locations of the former sewage disposal works, pumping station and refuse tip.</i> <i>Amosite and Chrysotile asbestos fibres were detected in TP10, TP15, TP17, TP20, TP26, TP27, WS08, and WS11. Asbestos fibres should be assumed to be site wide. Quantification is currently being undertaken.</i> <i>The proposed development is for a residential end use which include private gardens therefore a pollution linkage exists.</i>

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL2	Contaminated Soils	Inhalation of vapour.	Unlikely	Medium to Severe	Low	This pollution linkage refers to vapours migrating into confined spaces within the proposed development. Laboratory testing has not recorded hydrocarbons in the volatile range and no elevated volatile PAHs have been recorded, no elevated VOC or SVOC were recorded either. A plausible pollution linkage is not considered to exist.
PL3	Contaminated Soils	Inhalation of soil dust by adjacent site users.	Unlikely	Medium	Low	Pollution Linkage 3 relates to contamination on the subject site affecting adjacent site users. No mobile contamination has been identified and a pollution linkage has not been identified.
PL4	Contaminated Soils	Attacking potable water supply pipe.	Low Likelihood	Medium	Moderate	Pollution Linkage 4 refers to the possible contaminants permeating potable water pipes and consumption by the future site end users of the tainted water supply. Made Ground and olfactory evidence of contamination is present at water supply pipe installation depth. A local water company risk assessment should be undertaken to confirm the level of protection required.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential Source	Pollution Linkage	Likelihood	Consequence/ Severity	Risk Rating	Rationale and Action
PL5	Ground Gas	Migration and accumulation of ground gas in internal spaces.	Likely	Medium to Severe	Moderate to High	The site used to be an open cast quarry, an area of coal mine workings, a sewage disposal works and a refuse tip. Made Ground has been recorded to a maximum depth of 4.5m bgl. Ground gas monitoring carried out to date has classified the site as being in Characteristic Situation 2 and gas protection measures may be required. The level of precautions required will be confirmed on completion of the monitoring where it is likely that CS1 conditions or a zoning method of CS1 and CS2 conditions will be required. The latest radon maps launched by UKHSA indicate the northern part of the site to be in an area where the maximum radon potential is 3% to 5% and basic radon measures may be required within new buildings. It is recommended that a site-specific search is carried out through the BGS to determine the exact level of precautions required.

Controlled Waters Pollution Linkage Assessment



- The table below represents the second stage in the land quality risk assessment process – **Generic Quantitative Risk Assessment**.
- In order for a development site to be deemed 'suitable for use' the level of risk needs to be reduced to an acceptable level - low to negligible risk. The purpose of each stage of risk assessment is to establish if there is a requirement for additional stages of assessment in order to have sufficient confidence to support a risk characterisation or remedial action.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
PL6	Contaminated Soils	Impaction of groundwater from soil contamination (diffuse and point). Impaction of groundwater from groundwater plume.	Unlikely	Medium	Low	Made Ground has been encountered beneath the site to depths of up to 4.5m bgl. Gross mobile contamination has not been recorded. Geological maps indicate that the site is underlain by Glacial Till (Secondary Undifferentiated Aquifer) and the bedrock is the Pennine Lower Coal Measures Formation (Secondary A Aquifer). The site is not within a Source Protection Zone. Groundwater strikes were generally a seepage and were perched in the Made Ground. The Made Ground is generally underlain by natural Clay which will have prevented the downward migration of potential contamination to the Secondary A Aquifer. No realistic pollution linkage is considered to be present.

Conceptual Site Model					Generic Quantitative Risk Assessment	
PL	Potential source	Pollution linkage	Likelihood	Severity	Level of risk	Rationale
PL7	Contaminated Soils	Migration of soil and groundwater contamination impacting surface waters.	Unlikely	Medium	Low	<i>This pollution linkage relates to the Prescott Brook, which is located immediately offsite to the west, being affected by contaminated soils and groundwater.</i> <i>No mobile contamination was identified as part of the Ground Investigation and no viable pollution linkage exists.</i>

8.5 Outline Remedial Strategy

Soils

Made Ground was encountered beneath the site to a maximum depth of 4.5m bgl. Elevated levels of heavy metals and speciated PAHs have been recorded as part of this Ground Investigation and previous works carried out by e3p. In addition, Amosite and Chrysotile asbestos fibres have been detected in the Made Ground.

Proposed hardsurfacing (access roads, driveways and houses) will effectively act as a cover system. Where private gardens and Public Open Space are present, it is recommended that a cover system comprising 600mm of clean topsoil and subsoil overlying a contamination demarcation barrier or a 100mm hard dig layer is placed.

Any imported topsoil and subsoil should be tested to ensure that it is suitably clean for the proposed residential without plant uptake end use. In addition, the thickness of the cover system will need to be validated in accordance with YALPAG to ensure that it has been installed correctly.

Japanese Knotweed

Japanese Knotweed is present on THE site which will need to be treated and/or removed prior to construction commencing.

Ground Gas

Ground gas monitoring carried out to date indicates that the site falls into both Characteristic Situation 1 and Characteristic Situation 2, gas protection measures may be required within some of the new dwellings. Zonation of the site will be based on the final gas assessment.

The latest radon maps launched by UKHSA indicate the northern part of the site to be in an area where the maximum radon potential is 3% to 5% and basic radon measures may be required within new buildings. It is recommended that a site-specific search is carried out through the BGS to determine the exact level of precautions required.

Controlled Waters

A source of mobile contamination has not been identified and no remediation is required with respect to controlled waters.

Watching Brief and Regulatory Liaison

A watching brief is recommended during future ground works for any previously unseen contamination. If identified, work should cease in that area and advice sought from Groundtech Consulting.

Approval from the regulators should be obtained prior to the development commencing to avoid any delays at the construction stage.

8.6 Asbestos in Soils

Amosite and Chrysotile asbestos fibres have been detected in the Made Ground soils analysed as part of this Ground Investigation and previous work undertaken by e3p. Quantification is currently being carried out.

- *The use of qualified personnel where required.*
- *Careful segregation of stockpiles on site.*
- *Defining transport routes.*

- *Cleaning down of machinery in designated areas.*
- *Decontamination unit for ground workers.*
- *Damping down of soils to prevent dust migration.*

JIWG assessment tool will be undertaken on receipt of the asbestos quantifications and provide advice on the risk and asbestos control measures. The final decision on how asbestos within the soils should be managed should be made by the contractor.

8.7 Health and Safety - Construction and Ground Workers

During the reclamation and construction phases of the site development, it will be necessary to protect the health and safety of site personnel. The risk to construction and ground workers is assessed in the table below:

PL Ref	Potential Source	Pollution Linkage	Likelihood	Severity	Level of Risk
PL8	Made Ground	Ingestion, direct contact, inhalation of dusts.	Likely	Medium	Moderate
PL9	Asbestos	Ingestion, direct contact, inhalation of dusts.	Likely	Medium	Moderate

Elevated Contaminants of Concern have been recorded in the underlying Made Ground soils. In addition, Amosite and Chrysotile asbestos fibres were detected in the Made Ground. It is recommended that ground workers wear gloves when handling Made Ground soils and hand washing facilities are made available. The risk to ground workers should be communicated through a site induction and through information on noticeboards.

Asbestos control measures should be implemented to the satisfaction of the contractor as discussed in Section 8.6.

General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following measures are suggested to provide a minimum level of protection:

- *All ground workers should be issued with the relevant protective clothing, footwear and gloves. These protective items should not be removed from the site and personnel should be instructed as to why and how they are to be used.*
- *Hand-washing and boot-washing facilities should be provided.*
- *Care should be taken to minimise the potential for off-site migration of contamination by the provision of dust suppression control and wheel cleaning equipment during the construction works.*
- *Good practices relating to personal hygiene should be adopted on the site.*
- *The contractor shall satisfy the Health and Safety Executive with regard to any other matters concerning the health, safety and welfare of persons on the site.*

8.8 Waste Classification by Assessment

We have reviewed the testing results and inputted them into the HazWasteOnline model which allows users to code and classify waste as defined in the EWC (European Waste Catalogue 2002) based on EC Regulation 1272/2008 on the Classification, labelling and packaging of substances and mixtures (CLP) and latest

Environment Agency guidance (WM3 “Guidance on the classification and assessment of waste (1st edition 2015)-Technical Guidance”).

This is a useful tool as waste producers have the legal responsibility to classify any waste they produce.

Thirty five samples were tested to assess whether they contained any contaminants in the hazardous range when screened against assessment criteria within WM3. The results are in the Waste Classification Report presented in *Appendix 10*.

Location	Depth (m bgl)	Material	Classification	Hazardous Properties
TP01	0.30	Made Ground	Non-Hazardous	-
TP02	1.50	Made Ground	Non-Hazardous	-
TP03	1.00	Made Ground	Non-Hazardous	-
TP04	1.00	Made Ground	Non-Hazardous	-
TP06	0.50	Made Ground	Non-Hazardous	-
TP07	0.50	Made Ground	Hazardous	Zinc - Carcinogenic
TP08	1.00	Made Ground	Non-Hazardous	-
TP09	1.00	Made Ground	Hazardous	Zinc - Carcinogenic
TP10	2.50	Made Ground	Hazardous	Zinc - Carcinogenic
TP11	0.10	Made Ground	Hazardous	Zinc - Carcinogenic
TP13	2.00	Made Ground	Hazardous	Zinc - Carcinogenic
TP15	1.00	Made Ground	Non-Hazardous	-
TP16	0.80	Made Ground	Non-Hazardous	-
TP17	3.50	Made Ground	Non-Hazardous	-
TP20	1.00	Made Ground	Hazardous	Zinc - Carcinogenic
TP22	3.40	Made Ground	Non-Hazardous	-
TP23	3.00	Made Ground	Non-Hazardous	-
TP25	0.30	Made Ground	Non-Hazardous	-
TP25	3.00	Made Ground	Non-Hazardous	-
TP26	0.20	Made Ground	Non-Hazardous	-
TP27	1.50	Made Ground	Non-Hazardous	-
TP27	2.10	Made Ground	Non-Hazardous	-
TP28	1.80	Made Ground	Non-Hazardous	-
TP29	1.20	Made Ground	Non-Hazardous	-
TP29	2.00	Cohesive Natural	Non-Hazardous	-
WS01	0.70	Made Ground	Non-Hazardous	-
WS03	0.50	Made Ground	Non-Hazardous	-
WS03A	0.70	Made Ground	Non-Hazardous	-
WS06	0.90	Made Ground	Non-Hazardous	-
WS07	0.20	Made Ground	Non-Hazardous	-
WS08	1.80	Made Ground	Non-Hazardous	-
WS09	2.50	Made Ground	Non-Hazardous	-
WS11	0.30	Made Ground	Non-Hazardous	-
WS11	1.70	Made Ground	Non-Hazardous	-

WS12	0.60	Made Ground	Non-Hazardous	-
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Based on the assessment tool, six samples of the Made Ground have been classified as *Hazardous* for waste disposal purposes due to carcinogenic hazardous properties associated with the zinc content. This material mainly comprises dark brown granular Made Ground and was predominantly present in the southern area with the exception of TP20. Where possible, it is recommended that the Hazardous soils are left undisturbed in-situ.

One sample of the natural soils has been tested and has been classified as being *Non-Hazardous*.

Asbestos quantification is currently being carried out. If the quantification is greater than 0.1% mass, the soils will be classified as being Hazardous.

8.9 Waste Acceptance Criteria (WAC) Results

The Landfill Directive (Directive 1999/31/EC on the landfilling of waste) led to the establishment of a methodology for classifying wastes. Wastes can only be accepted at a landfill if they meet the relevant Waste Acceptance Criteria (WAC) for that type of landfill. There are three different WAC, these are for:

- *Inert waste*
- *Non-Hazardous waste*
- *Hazardous waste*

Waste Acceptance Criteria (WAC) testing was outside the scope of this investigation and the guidance given below is general.

The possibility of automatic inert classification of the natural soils should be explored in accordance with Section 4.3 of the EA guidance document. The Council Decision includes a list of wastes in Section 2.1.1 of the document that are assumed to be inert and therefore acceptable at a landfill for inert waste without testing, this is the case if:

- *They are single stream waste of a single waste type (although different waste types from the list may be accepted together if they are from a single source)*
and
- *There is no suspicion of material or substances such as metals, asbestos, plastics, chemicals, etc to an extent which increases the risk associated with the waste sufficiently to justify contamination and they do not contain other their disposal in other classes of landfill.*

If any organic contaminated material is encountered during the construction phase, it is possible that this may be classified as hazardous, and testing should be undertaken at that time.

Materials should be segregated and where necessary sufficient time is allowed to further classify the material properly, including discussion with landfill sites and waste transfer stations to find the best disposal route. It is recommended that where possible that the soils could be recycled at a suitable local waste treatment plant or transfer station rather than a landfill disposal route.

The reuse of soils on the site this should be done in accordance with the CL:AIRE "Development Industry Code of Practice for the Definition of Waste" (CL:AIRE CoP). Any re-use scheme should be designed to minimise disposal costs.



After a cut and fill balance plan/volume calculation has been carried out, a U1 and T5 exemption could be registered. This will allow the use of the following soils without a waste permit or under Dow CoP MMP:

- *1,000 tonnes (c.600m³) of non-hazardous soil*
- *5,000 tonnes (c.3,000m³) of natural sand and gravels.*
- *50,000 tonnes (c.25,000m³) of bituminous material to be used in roadways.*
- *5,000 tonnes (c.3,000m³) of crushed concrete / stone.*

9.0 FINAL APPRAISAL

9.1 Land Quality

Historically, the southern area of the site was occupied by Old Carrs Pit and a pumping station and the northern area contained a former Sewage Disposal Works.

Made Ground was encountered beneath the site to a maximum proven depth of 4.5m bgl and comprised granular and cohesive material with minor constituent of glass, plastic, wood, concrete, brick, ceramics, and metal. Olfactory evidence of hydrocarbon contamination was noted locally in the northern and eastern extent of the site. Colliery spoil was also encountered along the eastern boundary and in close proximity to the mine shafts. No other significant visual or olfactory evidence of potential contamination was noted during the Ground Investigation.

Based on the site having a residential with plant uptake end use - elevated levels of arsenic, lead, mercury nickel and speciated PAHs were encountered within the Made Ground beneath the site associated with the historic pumping station, sewage disposal works and refuse tip. Asbestos fibres were detected widespread in the Made Ground. The risk to Human Health is considered to be *Moderate to High*.

Significant mobile contamination has not been encountered and the risk to controlled waters is considered to be *Low*.

Three ground gas monitoring visits have been completed, based on the current results the site has been classified as falling into Characteristic Situation 2, this is based on the carbon dioxide concentrations recorded. One flow rate has been recorded and coincided with built up borehole pressure. The level of gas precautions required will be confirmed by the final gas assessment.

The latest radon maps launched by UKHSA indicate the northern part of the site to be in an area where the maximum radon potential is 3% to 5% and basic radon measures may be required within new buildings. It is recommended that a site-specific search is carried out through the BGS to determine the exact level of precautions required.

Japanese Knotweed is present on the site which will need to be treated and/or removed prior to construction commencing.

Based on the assessment tool, six samples of the Made Ground have been classified as *Hazardous* for waste disposal purposes due to carcinogenic hazardous properties associated with the zinc content. This material mainly comprises dark brown granular Made Ground and was mainly present in the southern area.

9.2 Ground Engineering

Mine Shafts

The location of two mine shafts was confirmed on the northern and southern areas of the site. The location of the two mine shafts along the eastern boundary was not successful. Further investigation is required with respect to the shaft on the northern area, and a watching brief maintained along the eastern boundary.

Workings

No evidence of workings have been recorded during the drilling to date, the risk is considered to be low for the southern area due to the coal likely being removed by opencast mining methods. Further investigation

is required in the northern area to confirm the absence of workings and also around the mine shaft to confirm the depth to bedrock.

Foundations

The most suitable solution for the proposed development in the southern area is considered to be partial depth treatment using Vibro-Stone Columna (VSCs) with a reinforced raft foundation above. As an alternative, piled foundation may also be a viable option, transferring loads through the Made Ground and natural Clay and Sand deposits to the Mudstone, Sandstone and siltstone bedrock which has been encountered from depths of between 4.5m and 13.3m bgl.

The top 2m to 3m of Made Ground requires turning over to remove obstructions on the northern area of the site. The materials should then be processed, classified and placed to an end product/performance specification. On completion of the earthworks, VSCs are considered suitable with reinforced strip foundations.

Concrete

As the soils beneath the site are potentially pyritic, the concrete classification for the site is ACEC Class AC-4 and sulphate class DS-4.

Highways and Pavements

Untreated Made Ground should be assumed to have a CBR value of less than 2.5%, unless proven otherwise and reengineering as part of the enabling works is required.

SuDS

The use of SuDS drainage is not considered to be a feasible option as the site is predominantly underlain by deep Made Ground which is contaminated underlain by natural cohesive ground.

9.3 Required Further Work

The following further work is considered necessary to progress the site to construction phase:

Completion of gas monitoring programme.

Issue gas assessment.

Commission a site-specific radon search through the BGS to confirm the level of precautions required.

Further investigation to determine the presence of workings, specifically in the northern area.

Investigation of the mine shaft on the northern area to inform treatment including to determine the depth to bedrock around the shaft.

Combustibility testing.

Further BRE testing to reduce concrete classification.

Further investigation of inaccessible areas due to vegetation/ecology.

Treatment or removal of Japanese Knotweed.

Preparation of a Remedial Specification.

Watching brief during enabling works particularly below obstructions associated with sewage disposal works and associated tanks/filter beds.

Confirmation of the recommendations made within this report with regulators.

10.0 RELEVANT INDUSTRY REFERENCES

- British Standards Institution. *Investigation of Potentially Contaminated sites - code of practice*. BS 10175:2017.
- British Standards Institution '*Code of Practice for Site Investigations*' BS 5930:2020
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APPENDIX 1 - Plans