

PHASE 2 ENGINEERING & ENVIRONMENTAL ASSESSMENT

FOR A RESIDENTIAL DEVELOPMENT AT THE FORMER MOUNT VERNON HOSPITAL, MOUNT VERNON ROAD, BARNSELY

CONTENTS

- 1.0 INTRODUCTION
- 2.0 LOCATION, TOPOGRAPHY & CURRENT CONDITION
- 3.0 GROUND INVESTIGATION
- 4.0 CONTAMINATION – DESIGN OBJECTIVES & PHILOSOPHY
- 5.0 DISCUSSION
- 6.0 CONTAMINATION ASSESSMENT
- 7.0 RECLAMATION PROPOSALS
- 8.0 ADDITIONAL INVESTIGATION WORKS REQUIRED
- 9.0 SUMMARY
- 10.0 CAVEATS

APPENDICES

- APPENDIX A - LIST OF DOCUMENTS REFERRED TO
- APPENDIX B - SITE LOCATION PLAN – FIG. 1
- APPENDIX C - SITE TOPOGRAPHICAL SURVEY – FIG. 2
- APPENDIX D - SITE AERIAL PHOTOGRAPH
- APPENDIX E - CODA STRUCTURES’ TRIAL PIT LOGS
- APPENDIX F - ARP & CODA STRUCTURES’ ROTARY BOREHOLE LOGS
- APPENDIX G - ARP & CODA STRUCTURES’ CHEMICAL TEST RESULTS
- APPENDIX H - CONTAMINATION ASSESSMENT CRITERIA FOR RESIDENTIAL USE WITH HOME GROWN PRODUCE

1.0 INTRODUCTION

- 1.01 Following instructions from Orion Homes Ltd on 15 July 2020, CoDA Structures have undertaken a supplemental Phase 2 intrusive investigation at a residential development site at the former Mount Vernon Hospital, Mount Vernon Road, Barnsley. The appraisal assesses engineering and environmental issues.
- 1.02 The former hospital buildings on the site have been recently demolished.
- 1.03 It is proposed to develop the site for housing.
- 1.04 A combined Stage 1/Stage 2 Geo-Environmental Report (Ref: SWY/02r1) dated 2 February 2018 for the site, a letter report (Ref: SWY/02/HMMjc) dated 12 March 2018 and a letter report (Ref: SWY/02/OG) dated 9 December 2018 has been prepared by ARP Chartered Consulting Engineers. These reports have been relied upon in the preparation of this report.
- 1.05 An additional trial pit ground investigation was undertaken on the site on 23 and 24 July 2020 by CoDA Structures to supplement the original investigations.
- 1.06 A further rotary borehole investigation was undertaken on the site on 14 September 2020.
- 1.07 The local authority is Barnsley Metropolitan Borough Council (BMBC).

2.0 LOCATION, TOPOGRAPHY & CURRENT CONDITION

- 2.01 The site is located to the west of Mount Vernon Road and lies approximately 1.0 mile to the south of Barnsley Town Centre. A site location plan (Fig. 1) is attached in Appendix B.
- 2.02 The Ordnance Survey co-ordinates for the centre of the site are 434960mE, 404750mN.
- 2.03 The site is approximately 2.7 hectares in area.
- 2.04 The site can be accessed from Mount Vernon Road
- 2.05 The site was a former NHS hospital. The hospital buildings were recently demolished.
- 2.06 The general fall of the site is to the southeast.
- 2.07 A site topographical survey (Fig 2) is attached in Appendix C.
- 2.08 A site aerial photograph is attached in Appendix D.

3.0 GROUND INVESTIGATION**3.01 Fieldwork:**

16 No. window sampling boreholes were sunk and 4 no. hand dug trial pits were excavated on the site by ARP on 15 and 16 November 2017.

9 No. rotary boreholes were drilled on the site by ARP on 14 and 16 November 2018.

The ARP trial pit, window sampling borehole and rotary borehole locations are indicated on Fig. 2 attached in Appendix C.

The ARP trial pit and window sampling borehole logs can be found in Appendix G of the APR report, reference SWY/02r1.

The APR rotary borehole logs are attached in Appendix F.

26 No. trial pits were excavated by CoDA Structures to depths of between 0.75 – 3.30m using a JCB 3CX excavator on 23 and 24 July 2018. The purpose of the trial pits was to allow an insitu visual inspection of the superficial soils, recover samples for laboratory testing and to undertake insitu testing. It should be noted TP21 was not excavated due to the presence of services.

The location of the CoDA Structures' trial pits are indicated on Fig. 2 attached in Appendix C.

3.02 Laboratory Testing:

To provide an assessment of soil contamination with respect to the proposed residential development soil samples were screened for a range of potential general contaminants. The screening included the following:-

Arsenic	Mercury	Zinc	PAH (16EPA)
Cadmium	Selenium	Boron (ws)	Asbestos
Chromium	Copper	Sulphate (ws)	TPH (speciated)
Lead	Nickel	pH	VOC's
			SVOC's

In view of the ground conditions encountered the following geotechnical no testing was undertaken.

3.03 Ground Conditions:

The following typical ground conditions were encountered on the site in the CoDA Structures' trial pit investigation:-

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Consulting Civil & Structural Engineers
14 Springfield Court
Guiseley
Leeds LS20 8FD

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
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VERNON ROAD, BARNSELEY**

Strata	Location						
	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Approx. Ground Level (m AOD)	158.45	158.50	158.50	19.00	158.35	158.50	158.50
Topsoil	0.00 – 0.15m	-	-	-	-	-	0.00 – 0.20m
Made Ground	0.15 – 1.00m	0.00 – 0.50m	0.00 – 2.40m	0.00 – 0.65m	0.00 – 1.70m	0.00 – 0.08m	0.20 – 0.80m
Sand	1.00 – 1.70m (sand, gravel and cobbles)	-	-	-	-	0.08 – 0.90m (sand)	-
Sandstone	1.70 – 2.40m (moderately weak to strong, slightly weathered to fresh)	0.50 – 0.75m (strong, slightly weathered to fresh)	2.40 – 3.30m (moderately weak to strong, fresh)	0.65 – 0.90m (strong, becoming very strong, fresh)	1.70 – 2.00m (strong and very strong, fresh)	0.90 – 1.60m (very strong with open fractures)	0.80 – 1.50m (strong with open fractures)
Stability	Pit walls stable whilst open	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls	Partial collapse of pit walls in made ground

Strata	Location						
	TP8	TP9	TP10	TP11	TP12	TP13	TP14
Approx. Ground Level (m AOD)	157.00	157.90	157.90	In hollow left by demolition-	157.90	157.20	155.70
Topsoil	-	-	-	-	-	-	-
Made Ground	0.00 – 1.65m	0.00 – 0.70m	0.00 – 0.10m	0.00 – 0.70m	0.00 – 0.03m	0.00 – 0.25m	0.00 – 2.65m
Sand	-	-	-	-	0.03 – 0.75m (sand, gravel, cobbles, possible made ground)	-	-
Sandstone	1.65 – 2.20m (moderately weak to strong, slightly weathered to fresh)	0.70 – 1.30m (moderately weak to strong with possible crown hole feature)	0.10 – 0.30m (very strong, fresh)	0.70 – 0.75m (very strong, fresh)	0.75 – 1.00m (moderately weak)	0.25 – 0.40m (moderately weak, slightly weathered)	2.65m (strong, fresh)
					1.00 – 1.20m (strong)	0.40 – 1.10m (moderately weak to strong with fracture zone)	
Stability	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Pit walls stable whilst open	Continual collapse of pit walls	Partial collapse of pit walls in made ground	Pit walls stable whilst open	Major collapse of pit walls

Strata	Location						
	TP15	TP16	TP17	TP18	TP19	TP20	TP22
Approx. Ground Level (m AOD)	156.80	157.30	157.30	154.00	154.30	157.30	154.30
Topsoil	-	-	-	-	-	-	-
Made Ground	0.00 – 2.00m	0.00 – 0.75m	0.00 – 1.30m	0.00 – 2.20m	0.00 – 1.40m	0.00 – 0.80m	0.00 – 1.50m
Sand	-	0.75 – 0.90m (sand)	1.30 – 1.45m (sand, gravel and cobbles)	-	-	0.80 – 1.10m (sand)	-
Sandstone	2.00 – 3.10m (strong with open fractures)	0.90 – 2.10m (moderate weak to strong, fresh with open joint fractures)	1.45 – 1.70m (very strong with open fractures)	-	1.40 – 2.00m (strong, highly to moderately weathered)	1.10 – 1.40m (strong, fresh)	1.50 – 1.55m (strong, fresh)
					2.00 – 2.20m (strong, fresh)		
Stability	Partial collapse of pit	Partial collapse of pit	Partial collapse of pit	Sudden, major	Partial collapse pit	Partial collapse of pit	Partial collapse of pit

Client: ORION HOMES LTD
Project No: 7861
Date: 12 October 2020

CoDa Structures

Consulting Civil & Structural Engineers
 14 Springfield Court
 Guiseley
 Leeds LS20 8FD

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 ASSESSMENT
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	walls in made ground	walls in made ground	walls in made ground	collapse of pit walls	walls in made ground	walls in made ground of	walls in made ground
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Strata	Location				
	TP23	TP24	TP25	TP26	TP27
Approx. Ground Level (m AOD)	145.50	156.00	154.30	153.75	150.35
Topsoil	-	0.00 – 0.40m	-	0.00 – 0.15m	-
Made Ground	0.00 – 0.30m	0.40 – 2.20m	0.00 – 1.10m	0.15 – 1.70m	0.00 – 1.60m
Sand	-	-	-	1.70 – 1.90m (sand and cobbles, possible made ground)	-
Sandstone	0.30 – 0.70m (strong, fresh)	2.20 – 2.30m (strong, fresh)	1.10 – 1.30m (strong, fresh)	1.90m?	1.60m (strong)
Stability	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Major collapse of pit walls	Partial collapse of pit walls in made ground

Topsoil was encountered in trial pits TP1, TP7, TP24 and TP26.

The made ground encountered on the site generally comprised of sand, sandstone gravel and cobbles, concrete gravel and fragments and occasional topsoil, plastic fragments, metal fragments, wood fragments, floor tile, tarmac fragments, brick fragments, ash cement bond asbestos and slate fragments.

A faint hydrocarbon odour was observed in TP8 at 1.60m.

For the detailed description of the strata encountered in the CoDA Structures' investigation see the trial pit logs attached in Appendix E.

The following ground conditions were encountered in the ARP and CoDA Structures' rotary borehole investigation:-

Borehole R01	
Strata	Thickness (m)
Made Ground	5.70
Sandstone	1.40
Mudstone	5.10
Coal	1.20
Mudstone	12.70
Coal	0.70
Mudstone	3.20
Drilled Depth	30.00

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 FORMER MOUNT VERNON HOSPITAL, MOUNT
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Borehole R02	
Strata	Thickness (m)
Made Ground	0.80
Sandstone	12.30
Mudstone	5.40
Coal	1.00
Mudstone	1.50
Drilled Depth	21.00

Borehole R03	
Strata	Thickness (m)
Made Ground	0.80
Sandstone	12.90
Mudstone	6.00
Coal	1.10
Mudstone	1.20
Drilled Depth	22.00

Borehole R04	
Strata	Thickness (m)
Made Ground	1.60
Sandstone	11.60
Mudstone	6.40
Coal	1.00
Mudstone	1.40
Drilled Depth	22.00

Borehole R05	
Strata	Thickness (m)
Topsoil	0.20
Made Ground	0.60
Sandstone	9.30
Mudstone	6.60
Coal	1.00
Mudstone	1.30
Drilled Depth	19.00

Borehole R06	
Strata	Thickness (m)
Made Ground	1.10
Sandstone	8.50
Mudstone	7.80
Coal	1.10
Mudstone	11.50
Drilled Depth	30.00

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Borehole R07	
Strata	Thickness (m)
Made Ground	1.40
Sandstone	12.00
Mudstone	6.20
Coal	1.00
Mudstone	1.40
Drilled Depth	22.00

Borehole R08	
Strata	Thickness (m)
Topsoil	0.20
Made Ground	1.10
Sandstone	13.40
Mudstone	6.60
Coal	1.00
Mudstone	1.70
Drilled Depth	24.00

Borehole R09	
Strata	Thickness (m)
Made Ground	5.80
Sandstone	3.90
Mudstone	4.00
Coal	1.00
Mudstone	5.30
Drilled Depth	20.00

Borehole R10	
Strata	Thickness (m)
Made Ground	0.40
Sandstone	4.80
Mudstone/Siltstone	7.80
Coal	0.80
Mudstone	3.00
Siltstone	0.80
Mudstone	5.80
Mudstone/Siltstone	4.70
Siltstone/Mudstone	1.90
Drilled Depth	30.00

Borehole R11	
Strata	Thickness (m)
Made Ground	1.00
Sandstone	3.50
Siltstone	3.30
Siltstone/Mudstone	1.70
Mudstone	4.00
Mudstone/Coal	1.00
Mudstone	2.60
Siltstone	2.90
Drilled Depth	20.00

Borehole R12	
Strata	Thickness (m)
Made Ground	0.60
Sandstone	10.40
Siltstone/Mudstone	7.00
Mudstone	1.00
Siltstone/Mudstone	1.00
Drilled Depth	20.00

The full description of the strata encountered is recorded on the Rotary Borehole Logs attached in Appendix F.

3.04 **Groundwater:**

Groundwater was not encountered in the ARP window sampling borehole investigation.

Groundwater was not encountered in the ARP hand dug trial pit investigation.

Groundwater was not encountered during the CoDA Structures' trial pit investigation.

Groundwater was not encountered in the ARP or CoDA Structures' rotary borehole investigation.

Groundwater was not encountered during the gas monitoring in ARP window sampling boreholes WS2, WS5, WS8 and WS13.

3.05 **Excavations:**

The sides of the trial pits were generally unstable in made ground horizons and major collapses occurred in the made ground in TP11, TP18 and TP26.

The sides of the trial pits were stable whilst open in TP1, TP10 and TP13.

3.06 Laboratory Testing:**Soils:**

The results of the chemical analyses on the soil samples, from both the ARP window sampling borehole investigation and CoDA Structures' trial pit investigation, are summarised below.

Chemical Test result certificates are attached in Appendix G.

Samples taken from the topsoil (WS1, WS2, WS3, WS4, WS5, WS6, WS7, WS8, WS9, WS11, WS15, WS16 – APP investigation; HS1, HS2, HS3 and HS4):-

Contaminant	Concentration in soils mg/kg*	No. of samples tested
Arsenic	8.3 – 19.0	17
Cadmium	<0.1 – 0.3	17
Chromium	6.1 – 23.0	17
Chromium Hexavalent	<1.0	17
Lead	23.0 - 120	17
Mercury	<0.05 – 0.21	17
Selenium	<0.5 – 0.9	17
Copper	16.0 – 59.0	17
Nickel	6.4 – 36.0	17
Zinc	35.0 – 210	17
Sulphate (Water Soluble)	<0.01 – 0.082 g/l	17
pH	6.6 – 8.4	17
PAH	<1.6 – 12.0	17
Phenols	<0.3 – 12.0	17

* unless stated otherwise

The results of sulphate and pH determinants indicate sulphate content expressed as 2:1 aqueous extract of between <0.01 and 0.082 g/l SO₄ with pH values between 6.6 and 8.4.

Samples taken from the made ground (WS1, WS2, WS4, WS12, WS13, WS15, WS16, WS17 – ARP investigation; TP2, TP3, TP4, TP5, TP8, TP11, TP14, TP16, TP17, TP18, TP22, TP24, TP25 and TP26):-

Contaminant	Concentration in soils mg/kg*	No. of samples tested
Arsenic	1.5 – 22.0	22
Cadmium	<0.1 – 0.8	22
Chromium	4.1 - 110	22
Chromium Hexavalent	<1.0	8
Lead	7.6 - 380	22
Mercury	<0.05 – 1.8	22
Selenium	<0.2 – 0.8	22
Copper	11.0 – 84.0	22
Nickel	2.2 – 19.0	22
Zinc	17.0 – 140	22
Boron (Water Soluble)	<0.4 – 1.1	22

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
FORMER MOUNT VERNON HOSPITAL, MOUNT
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Sulphate (Water Soluble)	<0.01 – 0.33 g/l	22
pH	7.7 – 11.8	22
PAH	<1.6 – 710	22
TPH	130	22
Asbestos	Not detected – detected	22
Phenols	0.3 – 0.5	8

* unless stated otherwise

The result of sulphate and pH determinations indicate sulphate content expressed as 2:1 aqueous extract of between <0.01 and 0.33 g/l SO₄ with pH values between 7.7 and 11.8.

Samples taken from the natural ground (WS3, WS9, WS13, WS17 – APP investigation; TP4, TP5, TP10, TP17 and TP25):-

Contaminant	Concentration in soils mg/kg*	Number of samples tested
Arsenic	1.9 – 7.0	5
Cadmium	<0.1	5
Chromium	2.9 – 13.0	5
Lead	2.0 – 15.0	5
Mercury	<0.1	5
Selenium	<0.2 – 0.37	5
Copper	4.3 – 17.0	5
Nickel	5.8 – 11.0	5
Zinc	3.3 – 32.0	5
Boron (Water Soluble)	<0.4	5
Sulphate (Water Soluble)	<0.01 – 0.044 g/l	9
pH	7.5 – 9.7	9
PAH	<1.6 - <2.0	5
Asbestos	Not detected	1

* unless stated otherwise

The results of a sulphate and pH determinations indicate a sulphate content expressed as 2:1 aqueous extract of between <0.01 and 0.044 g/l SO₄ with pH values between 7.5 and 9.7.

In view of the ground conditions encountered no geotechnical testing was undertaken.

3.07 Insitu Testing:

The results of SPT testing are summarised in the following table:-

Strata	N Value
Made Ground	45, 8, 24, 3, 6, 39, 9, 8, 8
Dense Sand	38
Sandstone	50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+, 50+

3.08 Gas Monitoring:

The gas monitoring results can be found in ARP letter report reference SWY/02/HMMjc.

4.0 CONTAMINATION - DESIGN OBJECTIVES & PHILOSOPHY**4.01 Identification of Potential Hazards:**

In January 2015 Land Quality Management Ltd (LQM) published Safe for Use Levels (S4UL's) for Human Health Risk Assessment introducing updated guidance for the assessment of risk to human health from land contamination. The S4UL's are based on assumptions on soil conditions, the existence of exposure pathways behaviour and type of contaminants. The apparent exceedence of the quoted S4UL's is taken as indicating that further detailed assessment is required or that remedial actions should be taken.

4.02 Sensitivity of Development:

The presence of elevated concentrations of particular analytes may present hazards in terms of personal health, damage to plant life and other environmental issues. The S4UL's are classified particular end uses as follows:-

Residential with home grown produce
Residential without home grown produce
Residential public open space
Allotments
Commercial/Industrial

4.03 Design Life:

It is important to recognise when considering a particular problem that the solution has finite life, a concept with which those in the construction industry are familiar. The design life is influenced by the materials used in construction, the environment and the degree of maintenance carried out to extend the design life.

Monitoring is required to determine whether a design is functioning correctly, commensurate with the prevailing environmental conditions. It is essential that future users are aware of today's solutions since historically most buildings and infrastructure works continue in service. The effect of an increased design life should not be allowed to prejudice the original design principles.

4.04 Legislation:

The principle legislation relating to a potential pollution and contamination problems addressed in the Environmental Protection Act 1990 and Environmental Act 1995.

For 'contaminated' land to exist a significant 'pollution linkage' must be present, that is, there should be a source of contamination, a pathway by which the contamination can migrate, to an identified 'receptor' where it could cause 'significant harm'.

Should any link within this chain be severed then the land may not strictly be regarded as 'contaminated land' under the Environmental Protection Act 1990.

Based on the historic site usage and activities on and in the vicinity of the site it was anticipated that there may be contamination present on site use.

A ground investigation was commissioned to investigate soils and the chemical constituents of these soils, especially any made ground. The site was not expected to be severally contaminated and therefore a comprehensive testing regime based on the current industry standard BS 10175 : 2001 was not considered necessary. However, a contamination survey was undertaken with a provision that return visits would have to be made if contamination was exposed at a sufficient concentration to justify more extensive investigations.

4.05 **Design Objectives:**

- i) The objective of reclamation works is to improve any marginal land into ground suitable for its use for residential use with home grown produce. The standards would be in accordance with the LQM/ CIEH S4UL's for Human Health Risk Assessment and SP1010: Development of Category 4 Screening Levels (C4SL's) for Assessment of Land Affected by Contamination as attached in Appendix H. The Assessment Criteria values are based upon an SOM of 1.0%. If considered appropriate a further quantitative risk assessment will be undertaken using calculated site specific target values or S4UL's for SOM values obtained for the site by laboratory testing.
- ii) Risk Assessment
A qualitative risk assessment of any contaminants identified on the site will be undertaken. This will consider the significance of the contaminants identified in terms of source, pathway, receptor (ie. pollution linkage).

5.0 **DISCUSSION**

5.01 **Soils:**

The investigation has revealed the presence of made ground on the site. The results have been assessed using the proposed Assessment Criteria for residential use with home grown produce attached in Appendix I.

The test results from samples taken from the topsoil on the site are compared in the following tables:-

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
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Contaminant	Concentration in soils mg/kg*	No. of samples tested	Assessment Criteria mg/kg	No. of samples exceeding Assessment Criteria
Arsenic	8.3 – 19.0	17	37	0
Cadmium	<0.1 – 0.3	17	26	0
Chromium	6.1 – 23.0	17	910	0
Chromium Hexavalent	<1.0	17	290	0
Lead	23.0 – 120	17	200	0
Mercury	<0.05 – 0.21	17	40	0
Selenium	<0.5 – 0.9	17	250	0
Copper	16.0 – 59.0	17	2400	0
Nickel	6.4 – 36.0	17	180	0
Zinc	35.0 – 210	17	3700	0
Sulphate (Water Soluble)	<0.01 – 0.082 g/l	17	-	-
pH	6.6 – 8.4	17	<5	0
PAH	<1.6 – 12.0	17	#	#
Phenols	<0.3 – 12.0	17	260	0

* unless stated otherwise

see following table

Speciated PAH analysis of samples from the topsoil on the site are summarised in the following table:-

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1	17	210	0
Acenaphthylene	<0.1	17	170	0
Anthracene	<0.1	17	2400	0
Benzo (a) Anthracene	0.2 – 0.5	17	7.2	0
Benzo (a) Pyrene	0.2 – 0.4	17	5.0	0
Benzo (b) Fluoranthene	0.2 – 0.4	17	2.6	0
Benzo (k) Fluoranthene	0.1 – 0.2	17	77.0	0
Benzo (g,h,i) Perylene	<0.1 – 0.2	17	320	0
Chrysene	<0.1 – 0.5	17	15.0	0
Di-benzo (a,h) Anthracene	<0.1	17	0.24	0
Indeno (1, 2, 3-cd) Pyrene	<0.1 – 0.2	17	27.0	0
Fluoranthene	0.3 – 1.1	17	280	0
Fluorene	<0.1	17	170	0
Napthalene	<0.1	17	2.3	0
Phenanthrene	0.1 – 0.9	17	95.0	0
Pyrene	0.3 – 0.9	17	620	0
Total	2.4 – 5.5	17	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the topsoil on the site.

Samples taken from the made ground on the site are assessed in the following table:-

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
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VERNON ROAD, BARNSELY**

Contaminant	Concentration in soils mg/kg*	No. of samples tested	Assessment Criteria mg/kg	No. of samples exceeding Assessment Criteria
Arsenic	1.5 – 22.0	22	37	0
Cadmium	<0.1 – 0.8	22	26	0
Chromium	4.1 - 110	22	910	0
Chromium Hexavalent	<1.0	8	21.0	0
Lead	7.6 - 380	22	200	2
Mercury	<0.05 – 1.8	22	40	0
Selenium	<0.2 – 0.8	22	250	0
Copper	11.0 – 84.0	22	2400	0
Nickel	2.2 – 19.0	22	180	0
Zinc	17.0 – 140	22	3700	0
Boron (Water Soluble)	<0.4 – 1.1	22	290	-
Sulphate (Water Soluble)	<0.01 – 0.33 g/l	22	-	-
pH	7.7 – 11.8	22	<5	0
PAH	<1.6 – 710	22	#	#
TPH	130	22	#	#
Asbestos	Not detected - detected	22	Detected	1
Phenols	0.3 – 0.5	8	260	0

* unless stated otherwise

see following table

Speciated PAH analysis of samples from the made ground site are summarised in the following table:-

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1	22	210	0
Acenaphthylene	<0.1 – 0.11	22	170	0
Anthracene	<0.1 – 1.0	22	2400	0
Benzo (a) Anthracene	<0.1 – 5.9	22	7.2	0
Benzo (a) Pyrene	<0.1 – 6.0	22	5.0	1
Benzo (b) Fluoranthene	<0.1 – 6.1	22	2.6	1
Benzo (k) Fluoranthene	<0.1 – 3.1	22	77.0	0
Benzo (g,h,i) Perylene	<0.1 – 3.4	22	320	0
Chrysene	<0.1 – 5.3	22	15.0	0
Di-benzo (a,h) Anthracene	<0.1 – 0.99	22	0.24	1
Indeno (1, 2, 3-cd) Pyrene	<0.1 – 3.5	22	27.0	0
Fluoranthene	<0.1 – 11.0	22	280	0
Fluorene	<0.1	22	170	0
Napthalene	<0.1 – 0.13	22	2.3	0
Phenanthrene	<0.1 – 2.5	22	95.0	0
Pyrene	<0.1 – 12.0	22	620	0
Total	<0.1 – 61.0	22	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce, the following determinants with levels in excess of Assessment Criteria were encountered in the made ground on the site:-

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
FORMER MOUNT VERNON HOSPITAL, MOUNT
VERNON ROAD, BARNSELY**

Lead	2 No.	WS15 TP14	0.90 – 1.10m 1.70m	380 mg/kg 220 mg/kg
Benzo (a) Pyrene	3 No.	WS17 TP14 TP22	0.30 – 0.50m 0.60m 0.60m	80 mg/kg 6.0 mg/kg 4.3 mg/kg
Benzo (a) Anthracene	1 No.	WS17	0.30 – 0.50m	74.0 mg/kg
Chrysene	1 No.	WS17	0.30 – 0.50m	69.0 mg/kg
Benzo (b) Fluoranthene	3 No.	WS17 TP14 TP22	0.30 – 0.50m 0.60m 0.60m	57.0 mg/kg 6.1 mg/kg 4.7 mg/kg
Indeno (1,2,3-cd) Pyrene	1 No.	WS17	0.30 – 0.50m	53.0 mg/kg
Di-benzo (a,h) Anthracene	4 No.	WS17 TP14 TP14 TP22	0.30 – 0.50m 0.60m 1.70m 0.60m	8.7 mg/kg 0.99 mg/kg 0.27 mg/kg 0.61 mg/kg
Asbestos	1 No.	TP14	1.70m	Chrysotile

In view of the above there is a significant pollution linkage present on the site in relation to Lead, Benzo (a) Anthracene, Benzo (a) Pyrene, Benzo (b) Fluoranthene, Chrysene, Indeno (1,2,3-cd) Pyrene and Di-benzo (a,h) Anthracene in the made ground on the site.

The presence of asbestos in TP14 is not of concern to end users as it was encountered at 1.70m below ground level. However, there should be vigilance with regard to possible asbestos based material during the construction works.

Samples taken from the natural ground on the site are compared in the following table:-

Contaminant	Concentration in soils mg/kg*	No. of samples tested	Assessment Criteria mg/kg	No. of samples exceeding Assessment Criteria
Arsenic	1.9 – 7.0	5	37	0
Cadmium	<0.1	5	26	0
Chromium	2.9 – 13.0	5	910	0
Lead	2.0 – 15.0	5	200	0
Mercury	<0.1	5	40	0
Selenium	<0.2 – 0.37	5	250	0
Copper	4.3 – 17.0	5	2400	0
Nickel	5.8 – 11.0	5	180	0
Zinc	3.3 – 32.0	5	3700	0
Boron (Water Soluble)	<0.4	5	290	-
Sulphate (Water Soluble)	<0.01 – 0.044 g/l	9	-	-
pH	7.5 – 9.7	9	<5	0
PAH	<1.6 - <2.0	5	#	#
Asbestos	Not detected	1	Detected	0

* unless stated otherwise

see following table.

Speciated PAH analysis of samples from the natural ground on the site are summarised in the following table:-

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
FORMER MOUNT VERNON HOSPITAL, MOUNT
VERNON ROAD, BARNSELY**

PAH 16 EPA	Concentrations in soils mg/kg	No. of Samples tested	Assessment Criteria mg/kg	No. of Samples exceeding Assessment Criteria
Acenaphthene	<0.1	5	210	0
Acenaphthylene	<0.1	5	170	0
Anthracene	<0.1	5	2400	0
Benzo (a) Anthracene	<0.1	5	7.2	0
Benzo (a) Pyrene	<0.1	5	5.0	0
Benzo (b) Fluoranthene	<0.1	5	2.6	0
Benzo (k) Fluoranthene	<0.1	5	77.0	0
Benzo (g,h,i) Perylene	<0.1	5	320	0
Chrysene	<0.1	5	15.0	0
Di-benzo (a,h) Anthracene	<0.1	5	0.24	0
Indeno (1, 2, 3-cd) Pyrene	<0.1	5	27.0	0
Fluoranthene	<0.1	5	280	0
Fluorene	<0.1	5	170	0
Napthalene	<0.1	5	2.3	0
Phenanthrene	<0.1	5	95.0	0
Pyrene	<0.1	5	620	0
Total	<0.1	5	-	-

When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the natural ground on the site.

Based on the assessment of the test results the following remediation measures are recommended on the site:-

- The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip to reduce residual levels of PAH compounds to those encountered in TP14 and TP22.
- Made ground in the area of WS15, WS17, TP14 and TP22, where retained in garden areas, should be capped with 0.6m of clean, inert material including 150mm of topsoil. The capping should be placed on a layer of Terram 1000. Alternatively, the made ground in each garden can be sampled and tested to establish whether a capping layer is required.
- However, there should be vigilance with regard to possible asbestos based material during the construction works.
- Service trenches should be backfilled with clean inert materials.

5.02 Controlled Waters:

Following the remediation works local to WS17, the levels of contamination encountered on the site are not considered to pose a significant risk to controlled waters.

5.03 Landfill Gas:

A summary of the monitoring results from the ARP report are shown in the table below.

Monitoring Point	Gas concentrations recorded (% v/v)		Flow rates recorded (litre/hour)
	Methane	Carbon Dioxide	
WS2	0.0	0.0 – 2.0	0.0
WS5	0.0	0.5 – 2.5	0.0
WS8	0.0	0.0 – 1.5	0.0
WS13	0.0	0.0	0.0

ND: None detected

Site Gas Regime:

Where Flow rates are shown as 0.0 a default value of 0.1 litres/hour has been used, representing the limit of detection of the measuring equipment.

The gas monitoring data has been appraised in order to assess the potential gas emission rate from the soils beneath the site.

Borehole gas screening values (GSV) for both methane and carbon dioxide have been calculated for each borehole and are shown in the table below.

Borehole No.:	Gas Screening Value – Methane (litre/hour)	Gas Screening Value – Carbon Dioxide (litre/hour)
WS2	0.0	0.0020
WS5	0.0	0.0025
WS8	0.0	0.0015
WS13	0.0	0.0000

Based on the maximum recorded concentrations of methane the site is categorised in accordance with the NHBC 'traffic light system' as Green.

Based on the GSVs obtained for methane the site is categorised in accordance with the NHBC 'traffic light system' as Green.

Based on the maximum recorded concentrations of carbon dioxide to date the site is categorised in accordance with the NHBC 'traffic light system' as Green.

Based on the GSVs obtained for carbon dioxide the site is categorised in accordance with the NHBC 'traffic light system' as Green.

5.03 Mining:

The mining search indicated the site is in a surface area that could be affected by underground mining in 8 seams of coal at shallow to 520m depth.

The rotary drilling on the site has not encountered any evidence of coal working in the two seams encountered below the site.

The following rock cover is present to the coal seams encountered as follows:-

Borehole	Competent Rock Cover	Seam Thickness (m)
R01	6.5	1.20
R01	12.7	0.70
R02	17.7	1.00
R03	18.9	1.10
R04	18.0	1.00
R05	15.9	1.00
R06	16.3	1.10
R07	18.2	1.00
R08	20.0	1.00
R09	7.9	1.00
R10	12.6	0.80
R11	12.5	1.00
R12	-	-

The upper seam (1.0 to 1.2m thick) encountered below the site generally has at least 12 x seam thickness of competent rock cover. However, upper seams in the southeast corner of the site, where the sandstone has been quarried, has less than 12 x seam thickness of competent rock cover.

The lower seam (0.7m thick) encountered below the site has at least 12 x seam thickness of competent rock cover separating it from the upper seam.

The open fractures and crown hole features recorded in the sandstone in the trial pits are indicative of historic ground movement from long wall mining which is known to have been carried out in the Barnsley area.

Foundation requirements in relation to the mining issues on the site are discussed in section 10.05.

5.04 Foundations:

The made ground on the site is not considered to be a suitable foundation strata as potentially damaging settlements could occur.

Where the depth of the made ground is not prohibitive, strip and trench footings can be adopted on the development, bearing on the underlying sandstone.

Where the ground has been disturbed by the removal of historic foundations, it is envisaged trench footings will be required.

Where 'deeper' made ground is present, due to the potential instability of excavations, the made ground would need to be reduced in level to facilitate the use of trench footing.

In view of the fractures encountered in the sandstone, potentially from long wall mining, it is recommended that footings should be mesh reinforced top and bottom in order to resist any potential small differential ground movement that may occur.

Where the depth of made ground is in excess of 2.0m it is recommended that piled foundations supporting reinforced concrete ground beams are utilised. It is envisaged that driven piles can be utilised, but advice should be sought from specialist piling contractors. As there is less than 12 x rock cover to a potentially worked coal seam below the made ground in the south eastern sector of the site, it is recommended that pile locations are pre-drilled so the piles can be founded below the level of the coal seam.

A safe working bearing pressure of 150 KN/m² can be adopted on the weathered bedrock.

5.05 **Ground Floor Construction:**

Due to the presence of made ground on the site and the fractured nature of the bedrock from potential long wall mining below the site, it is recommended a suspended ground floors with a 300mm minimum under floor void are utilised.

5.06 **Sulphate attack on Buried Concrete:**

The results of the sulphate analysis compared to BRE Special Digest 1, 'Concrete in Aggressive Ground' indicate Class DS-1 conditions and ACEC site classification AC-1s.

5.07 **Excavations:**

Whilst the trial pit walls were stable in the bedrock excavations in the made ground and sands on the site were unstable in the short term. Therefore, trench support should be provided in accordance with current Health & Safety Guidance.

Groundwater is unlikely to be encountered in foundation or drainage excavations. However, seepages should be expected in made ground horizons. It should also be noted that the groundwater table is likely to be subject to seasonal variations.

5.08 **Pavements:**

CBR values in the made ground are likely to be low (<2%) and variable. Where the made ground is below the adopted highway, subject to inspection and CBR testing, it

should be excavated to a maximum depth of 0.5m below the lowest sewer and replaced with well compacted 6F5 material.

CBR values in sands are likely to be reasonable (circa 3-5%). However, loose areas may be present in the granular strata which would require excavation and re-compaction.

CBR values in weathered bedrock are likely to be high (circa 5%+).

However, localised loose areas may be present in the granular made ground which would require excavation and re-compaction.

5.09 **Drainage:**

Due to the presence of fractured sandstone bedrock on the site the use of soakaways on the development may be feasible subject to testing in accordance with BRE 365 : Soakaways.

A conventional granular bed and surround can be adopted to drainage in re-engineered made ground and natural horizons.

6.0 **CONTAMINATION RISK ASSESSMENT**

6.01 **General:**

In order to evaluate the environmental risks identified during the investigation, a simple source-pathway-target model has been developed and is summarised at the end of this section in table form. The model has been used to determine significant pollutant linkages and identify suitable risk management proposals on which the remediation design is based.

6.02 **Sources:**

Chemical analyses of samples have indicated the presence of Lead in the topsoil on the site and elevated levels of Lead, Benzo (a) Anthracene, Benzo (b) Fluoranthene, Benzo (a) Pyrene, Chrysene, Indeno (1,2,3-cd) Pyrene, Di-benzo (a,h) Anthracene and Asbestos have been encountered in the made ground on the site.

6.03 **Pathways:**

The following potential contamination pathways have been identified on the site:-

Vertical migration pathways.

Human Uptake Pathways (derived from CLEA model and LQA for residential use):

- Ingestion of soil

- Ingestion of indoor dust
- Dermal contact with soil
- Contact with indoor dust
- Inhalation of vapours outside
- Inhalation of vapours inside
- Vertical and lateral migration of volatile vapours and ground gas
- Indirect ingestion
- Airborne hazardous fibres
- Plant root uptake.

6.04 **Targets:**

The following environmental receptors have been identified on site:-

- Groundwater residing in the underlying geology
- Buildings / structures
- Flora / Fauna
- Underground services
- Third party land.

The following human receptors have been identified on the site:-

- Construction workers
- Maintenance workers
- End users.

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Consulting Civil & Structural Engineers
 14 Springfield Court
 GUISELEY
 Leeds LS20 8FD

**PHASE 2 ENGINEERING & ENVIRONMENTAL ASSESSMENT
 FOR A RESIDENTIAL DEVELOPMENT AT THE
 FORMER MOUNT VERNON HOSPITAL, MOUNT VERNON ROAD, BARNESLEY**

11.05 Assessed Risk – Made Ground - Asbestos

SOURCES	PATHWAYS	TARGETS	LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCE	RISK RATING	RISK MANAGEMENT ACTION TAKEN
Topsoil	Direct Ingestion/ Inhalation or Contact	End Users	Unlikely	Severe	Low	There should be vigilance regarding the possible presence of asbestos based materials in the made ground on the site during the construction work.
	Direct Ingestion/ Inhalation or Contact	Construction workers	Likely	Severe	High	There should be vigilance regarding the possible presence of asbestos based materials in the made ground on the site during the construction work. Induction, PPR, high standard of personal hygiene.
	Indirect Ingestion	End Users	Unlikely	Severe	Low	There should be vigilance regarding the possible presence of asbestos based materials in the made ground on the site during the construction work.
	Indirect Ingestion	Construction workers	Likely	Severe	High	There should be vigilance regarding the possible presence of asbestos based materials in the made ground on the site during the construction work. Induction, PPE, high standard of personal hygiene.
	Root Uptake	Plants	Unlikely	Severe	Low	Asbestos is insoluble so will not be uptaken into planting.
	Vertical/ lateral migration to controlled waters	Aquifer	Unlikely	Medium	Low	Asbestos is insoluble.

Client: ORION HOMES LTD

Project No: 7861

Date: 12 October 2020

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14 Springfield Court
GUISELEY
Leeds LS20 8FD

PHASE 2 ENGINEERING & ENVIRONMENTAL ASSESSMENT FOR A RESIDENTIAL DEVELOPMENT AT THE FORMER MOUNT VERNON HOSPITAL, MOUNT VERNON ROAD, BARNSELEY

11.06 Assessed Risk – Made Ground – Lead, Benzo (a) Anthracene, Benzo (b) Fluoranthene, Benzo (a) Pyrene, Chrysene, Indeno (1,2,3-cd) Pyrene and Di-benzo (a,h) Anthracene

SOURCES	PATHWAYS	TARGETS	LIKELIHOOD OF OCCURRENCE	SEVERITY OF CONSEQUENCE	RISK RATING	RISK MANAGEMENT ACTION TAKEN
Made Ground	Direct Ingestion/ Inhalation or Contact	End Users	Likely	Severe	High	The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip. Local to WS15, WS17, TP14 and TP22, the made ground, where retained in garden areas should be capped with 0.6m of clean, inert material including 150mm of topsoil placed on a layer of Terram 1000 to reduce the risk to Low.
	Direct Ingestion/ Inhalation or Contact	Construction workers	Likely	Severe	High	The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip. Induction, PPR, high standard of personal hygiene.
	Indirect Ingestion	End Users	Low Likelihood	Severe	Moderate	The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip. Local to WS15, WS17, TP14 and TP22, the made ground, where retained in garden areas should be capped with 0.6m of clean, inert material including 150mm of topsoil placed on a layer of Terram 1000 to reduce the risk to Low.
	Indirect Ingestion	Construction workers	Low Likelihood	Severe	Moderate	The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip. Induction, PPE, high standard of personal hygiene.
	Root Uptake	Plants	Likely	Severe	High	The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip. Local to WS15, WS17, TP14 and TP22, the made ground, where retained in garden areas should be capped with 0.6m of clean, inert material including 150mm of topsoil placed on a layer of Terram 1000 to reduce the risk to Low.
	Vertical/ lateral migration to controlled waters	Aquifer	Unlikely	Medium	Low	The site is not within a Source Protection Zone.

Client: ORION HOMES LTD

Project No: 7861

Date: 12 October 2020

12.0 RECLAMATION PROPOSALS

The proposed works shall include the following, although this does not necessarily indicate the order or full extent of the works.

- Disconnect and/or divert any live services on the site.
- Grub out all vegetation and remove from site. Any vegetation to be retained, should be adequately protected from the works.
- Inspect the site for hazardous materials visible on the surface, remove from site together with any fly tipping and rubbish to a suitably licensed tip, using approved methods and a suitably licensed contractor.
- After the initial site strip the formation is to be inspected. Any areas of deleterious material or contamination not identified in the ground investigation identified by visual or olfactory evidence and subsequent chemical testing is to be remediated if necessary, in accordance with a risk assessment.
- Topsoil should be stockpiled for re-use on the development.
- The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip to reduce residual levels of PAH compounds to those encountered in TP14 and TP22.
- Made ground in the area of WS15, WS17, TP14 and TP22, where retained in garden areas should be capped with 0.6m of clean, inert material including 150mm of topsoil. The capping should be placed on a layer of Terram 1000. Alternatively, the made ground in each garden can be sampled and tested to establish whether a capping layer is required.
- Service trenches should be backfilled with clean inert materials.
- Any imported engineering fill material should be compacted in accordance with the Dpt. Highways Specification.
- Arisings from the made ground on the site may be classified as contaminated so guidance should therefore be sought from the local Waste Management Regulation Office regarding the disposal of soils from the site.

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Consulting Civil & Structural Engineers
14 Springfield Court
GUISELEY
LS20 8FD

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
FORMER MOUNT VERNON HOSPITAL,
MOUNT VERNON ROAD, BARNSELEY**

13.0 SUMMARY

Site Name & Location	Former Mount Vernon Hospital, Mount Vernon Road, Barnsley.						
Proposal	Housing						
Local Authority	Barnsley Metropolitan District Council						
Ground Conditions	The following typical ground conditions were encountered on the site in the CoDA Structures' trial pit investigation:-						
	Location						
Strata	TP1	TP2	TP3	TP4	TP5	TP6	TP7
Approx. Ground Level (m AOD)	158.45	158.50	158.50	19.00	158.35	158.50	158.50
Topsoil	0.00 – 0.15m	-	-	-	-	-	0.00 – 0.20m
Made Ground	0.15 – 1.00m	0.00 – 0.50m	0.00 – 2.40m	0.00 – 0.65m	0.00 – 1.70m	0.00 – 0.08m	0.20 – 0.80m
Sand	1.00 – 1.70m (sand, gravel and cobbles)	-	-	-	-	0.08 – 0.90m (sand)	-
Sandstone	1.70 – 2.40m (moderately weak to strong, slightly weathered to fresh)	0.50 – 0.75m (strong, slightly weathered to fresh)	2.40 – 3.30m (moderately weak to strong, fresh)	0.65 – 0.90m (strong, becoming very strong, fresh)	1.70 – 2.00m (strong and very strong, fresh)	0.90 – 1.60m (very strong with open fractures)	0.80 – 1.50m (strong with open fractures)
Stability	Pit walls stable whilst open	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls	Partial collapse of pit walls in made ground
	Location						
Strata	TP8	TP9	TP10	TP11	TP12	TP13	TP14
Approx. Ground Level (m AOD)	157.00	157.90	157.90	In hollow left by demolition-	157.90	157.20	155.70
Topsoil	-	-	-	-	-	-	-
Made Ground	0.00 – 1.65m	0.00 – 0.70m	0.00 – 0.10m	0.00 – 0.70m	0.00 – 0.03m	0.00 – 0.25m	0.00 – 2.65m
Sand	-	-	-	-	0.03 – 0.75m (sand, gravel, cobbles, possible made ground)	-	-
Sandstone	1.65 – 2.20m (moderately weak to strong, slightly weathered to fresh)	0.70 – 1.30m (moderately weak to strong with possible crown hole feature)	0.10 – 0.30m (very strong, fresh)	0.70 – 0.75m (very strong, fresh)	0.75 – 1.00m (moderately weak) 1.00 – 1.20m (strong)	0.25 – 0.40m (moderately weak, slightly weathered) 0.40 – 1.10m (moderately weak to strong with fracture zone)	2.65m (strong, fresh)
Stability	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Pit walls stable whilst open	Continual collapse of pit walls	Partial collapse of pit walls in made ground	Pit walls stable whilst open	Major collapse of pit walls
	Location						
Strata	TP15	TP16	TP17	TP18	TP19	TP20	TP22
Approx. Ground Level (m AOD)	156.80	157.30	157.30	154.00	154.30	157.30	154.30
Topsoil	-	-	-	-	-	-	-
Made Ground	0.00 – 2.00m	0.00 – 0.75m	0.00 – 1.30m	0.00 – 2.20m	0.00 – 1.40m	0.00 – 0.80m	0.00 – 1.50m
Sand	-	0.75 – 0.90m	1.30 – 1.45m	-	-	0.80 – 1.10m	-

Client: ORION HOMES LTD
Project No: 7861
Date: 12 October 2020

**PHASE 2 ENGINEERING & ENVIRONMENTAL
ASSESSMENT
FOR A RESIDENTIAL DEVELOPMENT AT THE
FORMER MOUNT VERNON HOSPITAL,
MOUNT VERNON ROAD, BARNSELEY**

		(sand)	(sand, gravel and cobbles)			(sand)	
Sandstone	2.00 – 3.10m (strong with open fractures)	0.90 – 2.10m (moderate weak to strong, fresh with open joint fractures)	1.45 – 1.70m (very strong with open fractures)	-	1.40 – 2.00m (strong, highly to moderately weathered) 2.00 - 2.20m (strong, fresh)	1.10 – 1.40m (strong, fresh)	1.50 – 1.55m (strong, fresh)
Stability	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Sudden, major collapse of pit walls	Partial collapse pit walls in made ground	Partial collapse of pit walls in made ground of	Partial collapse of pit walls in made ground

Strata	Location				
	TP23	TP24	TP25	TP26	TP27
Approx. Ground Level (m AOD)	145.50	156.00	154.30	153.75	150.35
Topsoil	-	0.00 – 0.40m	-	0.00 – 0.15m	-
Made Ground	0.00 – 0.30m	0.40 – 2.20m	0.00 – 1.10m	0.15 – 1.70m	0.00 – 1.60m
Sand	-	-	-	1.70 – 1.90m (sand and cobbles, possible made ground)	-
Sandstone	0.30 – 0.70m (strong, fresh)	2.20 – 2.30m (strong, fresh)	1.10 – 1.30m (strong, fresh)	1.90m?	1.60m (strong)
Stability	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Partial collapse of pit walls in made ground	Major collapse of pit walls	Partial collapse of pit walls in made ground

Topsoil was encountered in trial pits TP1, TP7, TP24 and TP26.

The made ground encountered on the site generally comprised of sand, sandstone gravel and cobbles, concrete gravel and fragments and occasional topsoil, plastic fragments, metal fragments, wood fragments, floor tile, tarmac fragments, brick fragments, ash cement bond asbestos and slate fragments. A faint hydrocarbon odour was observed in TP8 at 1.60m.

The following ground conditions were encountered in the ARP and CoDA Structures' rotary borehole investigation:-

Borehole R01	
Strata	Thickness (m)
Made Ground	5.70
Sandstone	1.40
Mudstone	5.10
Coal	1.20
Mudstone	12.70
Coal	0.70
Mudstone	3.20
Drilled Depth	30.00

Borehole R02	
Strata	Thickness (m)
Made Ground	0.80
Sandstone	12.30
Mudstone	5.40
Coal	1.00
Mudstone	1.50
Drilled Depth	21.00

Borehole R03	
Strata	Thickness (m)
Made Ground	0.80
Sandstone	12.90

Mudstone	6.00
Coal	1.10
Mudstone	1.20
Drilled Depth	22.00

Borehole R04	
Strata	Thickness (m)
Made Ground	1.60
Sandstone	11.60
Mudstone	6.40
Coal	1.00
Mudstone	1.40
Drilled Depth	22.00

Borehole R05	
Strata	Thickness (m)
Topsoil	0.20
Made Ground	0.60
Sandstone	9.30
Mudstone	6.60
Coal	1.00
Mudstone	1.30
Drilled Depth	19.00

Borehole R06	
Strata	Thickness (m)
Made Ground	1.10
Sandstone	8.50
Mudstone	7.80
Coal	1.10
Mudstone	11.50
Drilled Depth	30.00

Borehole R07	
Strata	Thickness (m)
Made Ground	1.40
Sandstone	12.00
Mudstone	6.20
Coal	1.00
Mudstone	1.40
Drilled Depth	22.00

Borehole R08	
Strata	Thickness (m)
Topsoil	0.20
Made Ground	1.30
Sandstone	13.40
Mudstone	6.60
Coal	1.00
Mudstone	1.70
Drilled Depth	24.20

Borehole R09	
Strata	Thickness (m)
Made Ground	5.80
Sandstone	3.90
Mudstone	4.00
Coal	1.00
Mudstone	5.30
Drilled Depth	20.00

Borehole R10	
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Consulting Civil & Structural Engineers
 14 Springfield Court
 GUISELEY
 LS20 8FD

**PHASE 2 ENGINEERING & ENVIRONMENTAL
 ASSESSMENT
 FOR A RESIDENTIAL DEVELOPMENT AT THE
 FORMER MOUNT VERNON HOSPITAL,
 MOUNT VERNON ROAD, BARNSELEY**

Strata	Thickness (m)
Made Ground	0.40
Sandstone	4.80
Mudstone/Siltstone	7.80
Coal	0.80
Mudstone	3.00
Siltstone	0.80
Mudstone	5.80
Mudstone/Siltstone	4.70
Siltstone/Mudstone	1.90
Drilled Depth	30.00

Borehole R11	
Strata	Thickness (m)
Made Ground	1.00
Sandstone	3.50
Siltstone	3.30
Siltstone/Mudstone	1.70
Mudstone	4.00
Mudstone/Coal	1.00
Mudstone	2.60
Siltstone	2.90
Drilled Depth	20.00

Borehole R12	
Strata	Thickness (m)
Made Ground	0.60
Sandstone	10.40
Siltstone/Mudstone	7.00
Mudstone	1.00
Siltstone/Mudstone	1.00
Drilled Depth	20.00

Groundwater was not encountered in the APR hand dug trial pit investigation.
 Groundwater was no encountered during the gas monitoring in ARP window sampling
 Groundwater was not encountered during the CoDA Structures' trial pit investigation.
 Groundwater was not encountered in the ARP or CoDA Structures' rotary borehole investigation.
 Groundwater was not encountered in the APR window sampling borehole investigation.
 boreholes WS2, WS5, WS8 and WS13.

Foundations	The made ground on the site is not considered to be a suitable foundation strata as potentially damaging settlements could occur. A safe working bearing pressure of 150 KN/m ² can be adopted on the weathered bedrock.
Ground Floor Construction	Due to the presence of made ground on the site and the fractured nature of the bedrock from potential long wall mining below the site, it is recommended a suspended ground floors with a 300mm minimum under floor void are utilised.
Building Near Trees	Not applicable.
Pavements	CBR values in the made ground are likely to be low (<2%) and variable. Where the made ground is below the adopted highway, subject to inspection and CBR testing, it should be excavated to a maximum depth of 0.5m below the lowest sewer and replaced with well compacted 6F5 material. CBR values in sands are likely to be reasonable (circa 3-5%). However, loose areas may be present in the granular strata which would require excavation and re-compaction. CBR values in weathered bedrock are likely to be high (circa 5%+). However, localised loose areas may be present in the granular made ground and sands which would require excavation and re-compaction.
Dewatering	Groundwater is unlikely to be encountered in foundation or drainage excavations. However, seepages should be expected in made ground horizons. It should also be noted that the groundwater table is likely to be subject to seasonal variations.
Excavations	The sides of the trial pits were generally unstable in made ground horizons and major collapses occurred in the made ground in TP11, TP18 and TP26.

	The sides of the trial pits were stable whilst open in TP1, TP10 and TP13.																																								
Sulphate Classification	The results of the sulphate analysis compared to BRE Special Digest 1, 'Concrete in Aggressive Ground' indicate Class DS-1 conditions and ACEC site classification AC-1s.																																								
Drainage	Due to the presence of fractured sandstone bedrock on the site the use of soakaways on the development may be feasible subject to testing in accordance with BRE 365: Soakaways. A conventional granular bed and surround can be adopted to drainage in re-engineered made ground and natural horizons.																																								
Contamination Assessment	<p>When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the topsoil on the site.</p> <p>When compared with the proposed Assessment Criteria in relation to residential use with home grown produce, the following determinants with levels in excess of Assessment Criteria were encountered in the made ground on the site:-</p> <table border="1"> <tr> <td>Lead</td> <td>2 No.</td> <td>WS15 TP14</td> <td>0.90 – 1.10m 1.70m</td> <td>380 mg/kg 220 mg/kg</td> </tr> <tr> <td>Benzo (a) Pyrene</td> <td>3 No.</td> <td>WS17 TP14 TP22</td> <td>0.30 – 0.50m 0.60m 0.60m</td> <td>80 mg/kg 6.0 mg/kg 4.3 mg/kg</td> </tr> <tr> <td>Benzo (a) Anthracene</td> <td>1 No.</td> <td>WS17</td> <td>0.30 – 0.50m</td> <td>74.0 mg/kg</td> </tr> <tr> <td>Chrysene</td> <td>1 No.</td> <td>WS17</td> <td>0.30 – 0.50m</td> <td>69.0 mg/kg</td> </tr> <tr> <td>Benzo (b) Fluoranthene</td> <td>3 No.</td> <td>WS17 TP14 TP22</td> <td>0.30 – 0.50m 0.60m 0.60m</td> <td>57.0 mg/kg 6.1 mg/kg 4.7 mg/kg</td> </tr> <tr> <td>Indeno (1,2,3-cd) Pyrene</td> <td>1 No.</td> <td>WS17</td> <td>0.30 – 0.50m</td> <td>53.0 mg/kg</td> </tr> <tr> <td>Di-benzo (a,h) Anthracene</td> <td>4 No.</td> <td>WS17 TP14 TP14 TP22</td> <td>0.30 – 0.50m 0.60m 1.70m 0.60m</td> <td>8.7 mg/kg 0.99 mg/kg 0.27 mg/kg 0.61 mg/kg</td> </tr> <tr> <td>Asbestos</td> <td>1 No.</td> <td>TP14</td> <td>1.70m</td> <td>Chrysotile</td> </tr> </table> <p>In view of the above there is a significant pollution linkage present on the site in relation to Lead, Benzo (a) Anthracene, Benzo (a) Pyrene, Benzo (b) Fluoranthene, Chrysene, Indeno (1,2,3-cd) Pyrene, Di-benzo (a,h) Anthracene and Asbestos in the made ground on the site. The presence of asbestos in TP14 is not of concern to end users as it was encountered at 1.70m below ground level.</p> <p>When compared with the proposed Assessment Criteria in relation to residential use with home grown produce no determinants with levels in excess of Assessment Criteria were encountered in the natural ground on the site.</p>	Lead	2 No.	WS15 TP14	0.90 – 1.10m 1.70m	380 mg/kg 220 mg/kg	Benzo (a) Pyrene	3 No.	WS17 TP14 TP22	0.30 – 0.50m 0.60m 0.60m	80 mg/kg 6.0 mg/kg 4.3 mg/kg	Benzo (a) Anthracene	1 No.	WS17	0.30 – 0.50m	74.0 mg/kg	Chrysene	1 No.	WS17	0.30 – 0.50m	69.0 mg/kg	Benzo (b) Fluoranthene	3 No.	WS17 TP14 TP22	0.30 – 0.50m 0.60m 0.60m	57.0 mg/kg 6.1 mg/kg 4.7 mg/kg	Indeno (1,2,3-cd) Pyrene	1 No.	WS17	0.30 – 0.50m	53.0 mg/kg	Di-benzo (a,h) Anthracene	4 No.	WS17 TP14 TP14 TP22	0.30 – 0.50m 0.60m 1.70m 0.60m	8.7 mg/kg 0.99 mg/kg 0.27 mg/kg 0.61 mg/kg	Asbestos	1 No.	TP14	1.70m	Chrysotile
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Controlled Waters	Following the remediation works local to WS17, the levels of contamination encountered on the site are not considered to pose a significant risk to controlled waters.																																								
Remediation Proposals	<p>Based on the assessment of the test results the following remediation measures are recommended on the site:-</p> <ul style="list-style-type: none"> - The made ground local to WS17 should be excavated and removed from site to a suitably licensed tip to reduce residual levels of PAH compounds to those encountered in TP14 and TP22. - Made ground in the area of WS15, WS17, TP14 and TP22, where retained in garden areas should be capped with 0.6m of clean, inert material including 150mm of topsoil. The capping should be placed on a layer of Terram 1000. Alternatively, the made ground in each garden can be sampled and tested to establish whether a capping layer is required. - There should be vigilance with regard to possible asbestos based material during the construction works - Service trenches should be backfilled with clean inert materials. 																																								
Remediation Statement	Required.																																								
Gas Protection	No protection measures are required on the development.																																								
Radon	No protection measures are required on the development.																																								
Unforeseen Circumstances	Should any areas of previously unidentified potentially contaminated soil be encountered during site construction works we would recommend consultation with CoDA Structures to ensure that the recommendations continue to apply.																																								
Construction	It is recommended that construction personnel with direct contact with the soils at the site use																																								

Works	appropriate PPE equipment (i.e. gloves and overalls) together with welfare facilities in accordance with general health and safety guidelines.
Utilities	We would recommend that a copy of the ground investigation report when available, is supplied to Utility Companies, and that their recommendations relating to appropriate supply pipes are adhered to.
Statutory Consultation	We would recommend that a copy of the ground investigation report once prepared is issued to the Local Authority for comment and approval prior to the development of the site.

14.0 CAVEATS

- 14.01 The comments given in this report and recommendations made are based on the information that could be obtained from reasonably accessible sources. Discussions have not yet been held with statutory bodies and the local authority.
- 14.02 The comments and recommendations made in this report are based on the ground conditions encountered during the site work, and on the results of laboratory testing on a selected number of samples taken in the field. There may be conditions prevailing at the site with respect to ground conditions and contamination that have not been encountered during the investigations, and which have therefore not been taken into account in this report.
- 14.03 This report has been prepared for the sole use of Orion Homes Ltd and their development funders, unless agreed otherwise in writing by CoDA Structures.

Jan Lawrence

Signed:
 J Lawrence B Eng C Eng M I Struct E