



VALENCIA WASTE MANAGEMENT LTD

PILSWORTH LANDFILL SITE, BURY

PHASE II GROUND INVESTIGATION REPORT

MAY 2024

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DRAWINGS

DRAWING NO.	TITLE	SCALE
GM13005-002	As Built Ground Investigation Location	1 : 500 @ A3
GM13005-003	Site Location Plan	1 : 1,000 @ A3

1 INTRODUCTION

1.1 Instruction and Background

- 1.1.1 Wardell Armstrong LLP (WA) were commissioned by INNOV8 Planning Ltd on behalf of Valencia Waste Management Ltd (VWM), hereafter referred to as the 'Client', to undertake a preliminary ground investigation at Pilsworth Landfill Site, Bury.

1.2 Proposed Development

- 1.2.1 The proposed development is for a Material Recovery Facility (MRF) with associated infrastructure as shown on client drawing 'Proposed MRF Location Option 1 (Drawing Number: PWS105)' dated 08 April 2023, attached at Appendix A.

1.3 Scopes and Objectives

- 1.3.1 The purpose of this ground investigation is to provide a preliminary assessment of the likely ground conditions present across the site to provide general geotechnical and geo-environmental information to support the identification of potential ground related development constraints.

1.4 Site Location and Description

- 1.4.1 The area of the proposed MRF and associated infrastructure, hereafter referred to as the 'Site', is located within Pilsworth Landfill Site, Bury, operated by VWM, c. 2.5 km southeast of the Bury (National Grid Reference: SD 82262 09026). The postcode of Pilsworth Landfill Site is BL9 8QZ.
- 1.4.2 The site comprises approximately 0.35 hectares of undeveloped land, with site currently consisting of gravel hardstanding and is used to store old tyre stockpiles, concrete debris, metal debris, plastic pipes, landfill liners, hardcore from previous screening, and machinery. The site is also adjacent to the active landfill cells. The site is bordered by the following:
- North: Landfill site entrance and Pilsworth Road.
 - South: Concrete and hardcore car parking, weighbridge, and site office.
 - East: Landfill cells, vegetation and grassland.
 - West: M66 Motorway.

1.5 Limitations

- 1.5.1 This report has been prepared for the exclusive benefit of the Client, for the purpose of providing geotechnical and geo-environmental recommendations for the site. The

report contents shall only be used in that context. Furthermore, new information, changes in practice or new legislation may necessitate revised interpretation of the report after the date of its production.

- 1.5.2 It should be noted that ground investigation relies upon the determination of information from 'point sources' such as the trial pits and boreholes and the interpretation of data between investigation points. It should be recognised that the actual conditions at, and between, investigation points can differ spatially and temporally. The assessments and recommendations given in this report are based upon the interpretation of the results from the ground investigation at a specific point and time and therefore any conclusions drawn would need to be reviewed prior to their use for further development of the site.
- 1.5.3 WA has carried out an appropriate level of checking of third party supplied information, however WA cannot be held liable for any inaccuracies, inconsistencies or omissions in such information (should there be any).
- 1.5.4 The GI was restricted in places due the presence of above ground obstructions such as the old tyre stockpiles, concrete debris, metal debris, plastic pipes, landfill liners, hardcore from previous screening, and machinery.
- 1.5.5 Exploratory hole locations were positioned to avoid these constraints and minimise disruption to the current land uses.
- 1.5.6 This report does not consider broader development constraints such as services, land drainage, detailed flood risk, ecology, invasive weeds, archaeology, acoustics or air quality.
- 1.5.7 WA has used reasonable skill and care in the design of the ground investigation work to comply with currently available industry guidance and to meet the requirements of the commission.

2 BASELINE CONDITIONS

2.1 Summary of the WA Phase 1 Desk Study

2.1.1 A summary of the site history, existing land use, geology, hydrogeology, hydrology and mining is contained within the WA 'Phase 1 Desk Study' (reference: GM12887-RPT-001) dated July 2023, attached at Appendix B. The Desk Study report should be read in conjunction with this report.

Geoenvironmental

2.1.2 A Conceptual Site Model was developed for the site which established the following potential sources of contamination at the site:

- Made ground associated with the adjacent land use.
- Pilsworth landfill cells and leachate tanks.
- Ground gas associated with made ground and potential presence of mine gas.
- Landfill gas associated with adjacent landfilling activities.

2.1.3 A preliminary qualitative risk assessment classified the site as low to moderate risk.

Coal Mining

2.1.4 A Coal Mining Risk Assessment (CMRA) was completed for the site (attached within Appendix B), which suggests a moderate risk to the site of ground instability and damage to infrastructure due to the following:

- Potential unrecorded mine entries; and
- Potential unrecorded shallow mine workings beneath the site in the Arley Seam.

Geotechnical

2.1.5 The Desk Study research suggests a moderate to high geotechnical risk to the proposed development. The following potential geotechnical constraints were identified in the Desk Study report:

- Made ground deposits of unknown composition and extent associated with historic infilled ground.
- Moderate risk of ground compressibility associated with made ground.
- Possible unrecorded shallow mine workings beneath the site in the Arley seam.

2.1.6 The Desk Study recommended a detailed ground investigation to determine the geological conditions, mining situation and the potential for contamination on site as well as a programme of gas and groundwater monitoring.

3 PHASE II GROUND INVESTIGATIONS

3.1 Description of Works

3.1.1 The ground investigation works were designed to provide a general classification of the ground conditions and mining situation on site. Selective boreholes (LCP03 – 05) were positioned to confirm the presence / absence of the Arley Seam beneath the south west of the site.

3.1.2 The ground investigation work comprised the following:

- A total of seven trial pits (TPs) were excavated on the 13 February 2024 under the full-time supervision of a WA Engineering Geologist (photos are attached as Appendix C and logs are attached at Appendix D). The TPs were excavated to a maximum depth of 4.00mbgl in order to:
 - Investigate the nature, distribution and thickness of near surface strata/backfill; and
 - Obtain samples for contamination analysis.

TP05 was not completed due to issues relating to the GPR survey.

- A total of five light cable percussive (LCP) boreholes (BHs) were drilled to a maximum depth of 29.80mbgl under the part-time supervision of a WA Engineer (logs are attached at Appendix E). The drilling was undertaken by Geotron (UK) Ltd between 12 February to 7 March 2024. The boreholes were drilled in order to:
 - Investigate the nature, distribution and thickness of near surface strata;
 - Allow the installation of gas and groundwater monitoring apparatus;
 - Obtain samples for laboratory testing; and
 - Carry out in-situ geotechnical testing (Standard Penetration Tests (SPTs) were undertaken in order to provide information on the density of the natural superficial deposits).
- A total of three rotary BHs were drilled following on from the LCP boreholes, to a maximum depth of 55.00mbgl under the part-time supervision of a WA Engineer (logs are attached at Appendix E). The drilling was undertaken by Geotron (UK) Ltd between 21 February to 4 March 2024. LCP boreholes were advanced by rotary open-hole (ROH) methods to a maximum depth of 55.00mbgl. The boreholes were drilled in order to:
 - Investigate the nature of the underlying solid strata; and
 - Confirm the presence / absence of the Arley Seam and the potential for

unrecorded shallow workings underlying the site as outlined in the WA Phase 1 Desk Study.

- Laboratory contamination testing was undertaken on selected samples collected from the TPs from across the site. The following suite of laboratory contamination testing was undertaken:
 - Heavy Metals (As, B, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn);
 - Soil Organic Matter (SOM);
 - Volatile Organic Compounds (VOCs);
 - Sulphide;
 - Water Soluble Sulphate;
 - Acid Soluble Sulphate;
 - pH;
 - USEPA 16 Polycyclic Aromatic Hydrocarbons (PAHs);
 - Poly Chlorinated Hydrocarbons (PCBs)
 - Asbestos ID; and
 - Total Petroleum Hydrocarbons (TPHs).

In total, nine solid samples were subject to analysis. A summary of the laboratory contamination testing is attached at Appendix F. Analysis was also undertaken on four water samples for TPH, CWG, SVOCs, VOCs, Sulphate and pH. The results are attached at Appendix F.

- Laboratory geotechnical testing was undertaken on selected samples from the TPs and LCP BHs from across the site. The following testing suite was undertaken to provide general classification of the site:
 - A total of 14 natural moisture contents; and
 - A total of 17 particle size distributions.

A summary of the laboratory geotechnical results is attached at Appendix G.

- Gas and groundwater monitoring standpipes were installed within all of the LCP BHs in order to:
 - Provide a representative monitoring grid across the site;
 - Determine the depth of groundwater beneath the site;
 - Obtain samples for laboratory water testing; and
 - Determine the gas regime beneath the site.

Gas and groundwater monitoring was undertaken on six occasions between 19 March 2024 and 23 April 2024. The results of the monitoring are attached at Appendix H.

4 GROUND INVESTIGATION RESULTS

4.1 Ground Conditions – Strata Profile

4.1.1 Details of the ground conditions encountered are provided in the WA Trial Pit Logs attached as Appendix D and in the Geotron (UK) Ltd Borehole Logs attached as Appendix E and are summarised in Table 4.1 below.

Table 4.1: Summary of Ground Conditions				
Strata	Typical Description	Depth (mbgl) *		Thickness (m)
		Top	Base	
Made Ground *	Dark grey fine to coarse SAND and angular fine to coarse GRAVEL of brick, tiles (possible ACM), plastic, glass and metal with medium cobbles content. Cobble angular of brick and concrete.	0.00 (All locations)	0.05 (TP06) to 1.30 (TP03)	0.05 (TP06) To 1.30 (TP03)
Sand	Reddish brown fine to medium SAND. Light yellowish brown gravelly fine SAND. Gravel is subangular fine to coarse of millstone grit.	0.05 (TP06) to 1.30 (TP03)	4.00 (TP01) to 23.30 (CP05)	2.00 (TP01) to 10.80 (CP01)
Clay	Soft grey silty sandy CLAY with low cobble content. (DD) Firm/stiff dark grey/brown boulder CLAY. (DD) Stiff/very stiff grey/brown boulder CLAY. (DD)	8.10 (CP02) to 20.30 (CP01)	14.50 (CP02) to 28.50 (CP01)	1.50 (CP05) to 7.00 (CP04)
Gravel	Brown coarse SAND and sub-angular to rounded GRAVEL with low cobble content. Fine sand and gravels (DD) Large cobbles with gravels and sands (DD)	5.20 (CP03) to 14.80 (CP01)	15.00 (CP02) to 20.00 (CP01)	2.00 (CP04) to 5.40 (CP01)
Bedrock (DD)	Very stiff grey MUDSTONE. Very hard MUDSTONE. Grey weathered MUDSTONE. Grey MUDSTONE.	28.30 (CP01) to 28.50 (CP03)	55.00 (CP01)	N/A
	Hard grey SANDSTONE.	34.50 (CP01) to 48.50 (CP03)	45.10 (CP04) to 52.20 (CP03)	1.10 (CP01) to 1.90 (CP03)
* Maximum observed depth of 4.00mbgl in TPs. DD = Driller Description				

Made Ground

- 4.1.2 Made ground was encountered at all locations and was generally encountered from ground level to 1.00m below ground level (mbgl) with a maximum depth of 1.30mbgl. The depth of the made ground varied across the site, however, all units contained similar sand and gravel components. This layer consisted of dark grey fine to coarse SAND and angular fine to coarse GRAVEL of brick, tiles (possible asbestos containing material (ACM)), plastic, glass and metal with medium cobble content. Cobbles were angular of brick and concrete.

Natural Superficial Deposits (NSDs)

- 4.1.3 NSDs were encountered in all locations from 0.05mbgl to 29.80mbgl. The NSDs were encountered below the made ground and consisted of sands followed by clays and gravels in varying order. The main unit encountered consisted of a reddish brown fine to medium SAND with another unit encountered within TP6 and TP7 which consisted of light yellowish brown gravelly fine SAND. Gravel is subangular fine to coarse of Millstone Grit. The clays were encountered in all the borehole locations at various depths along with sands and gravels.

Bedrock

- 4.1.4 Drillers logs describe the majority of the bedrock across the site as either a grey weathered to hard mudstone or hard sandstone, becoming more solid with depth.

Mining

- 4.1.5 ROH BH's were drilled following on from the LCP BHs to confirm the presence / absence of the Arley Seam and potential for shallow unrecorded workings at the site.
- 4.1.6 There was no conclusive evidence of coal seams of significant thickness or unrecorded workings encountered during the drilling. The drillers recorded smooth and steady drilling throughout the ROH BHs, suggesting no potential workings were encountered.
- 4.1.7 No seams were encountered in any of the BHs during the drilling process.

4.2 In-situ Testing

Standard Penetration Tests (SPTs)

- 4.2.1 SPTs have been carried out in all boreholes within the NSDs. Uncorrected SPT "N Values" range from 8 to refusal with a summary of the SPT results provided in Table 4.2.

Table 4.2: Summary of SPT Results		
Depth Range (mbgl)	N Value	
	Range	Average
1.00 – 1.45	20 - 49	36
2.00 – 2.45	9 – 50	26
3.00 – 3.45	17 - 26	21
4.00 – 4.45	12 - 26	21
5.00 – 5.45	20 - 30	20
6.50 – 6.95	12 - 50	30
7.50 – 7.95	25	25
8.00 – 8.45	17 - 32	25
9.50 – 9.95	13 - 38	23
10.00 – 10.45	20	20
11.00 – 11.45	17 - 46	27
12.50 – 12.95	19 - 47	29
13.00 – 13.45	27 - 29	28
14.00 – 14.45	22 - 50	34
15.50 – 15.95	27 - 49	39
16.00 – 16.45	31	31
17.00 – 17.45	29 - 38	34
18.50 – 18.95	22 - 50	40
19.00 – 19.45	34 - 50	42
20.00 – 20.45	9 - 50	35
21.50 – 21.95	8 - 50	34
22.00 – 22.45	46 - 50	48
23.00 – 23.45	13 - 50	31
24.50 – 24.95	50	50
25.00 – 25.45	48 - 50	49
26.00 – 26.45	49 - 50	50
27.50 – 27.95	50	50
28.00 – 28.45	50	50
29.00 – 29.45	50	50

Falling Head Tests (FHTs)

- 4.2.2 FHTs were also taken at 1.20mbgl in each borehole location to determine if infiltration drainage would be suitable for the site. The result of these tests can be seen in Table 4.3.

Table 4.3: Falling Head Test Results

Borehole	Date / Time of Tests		Duration and Fall	
	Start	Finish	Duration	Falling Head
CP01	15:45 (19/02/24)	08:00 (20/02/24)	16 hrs 15 mins	0 cm
CP02	16:30 (26/02/24)	08:00 (27/02/24)	15 hrs 30 mins	2 cm
CP03	10:00 (23/02/24)	12:00 (23/02/24)	2 hrs	0.9 cm
CP04	16:00 (26/02/24)	08:00 (27/03/24)	16 hrs	2 cm
CP05	16:05 (21/02/24)	08:00 (22/02/24)	15 hrs 55 mins	11 cm

4.3 Laboratory Geotechnical Testing

4.3.1 A summary of the laboratory geotechnical testing undertaken, along with the range and average test results are detailed in Sections 4.3.2 and 4.3.3. The laboratory geotechnical test results are contained in Appendix G.

Natural Moisture Content (NMC)

4.3.2 In total, 14 No. samples were scheduled for NMC testing. The NMC ranged from 5.1 – 23.0 % with an average result of 14.0 %.

Particle Size Distribution (PSD) and Sedimentation

4.3.3 In total, 18 No. samples from site were scheduled for PSD testing. A summary of the material classifications according to Table 6/2 of the Manual of Contract Documents for Highway Works (MCHW) Volume 1 Specification for Highway Works (SHW) is detailed in Table 4.4. This shows that the majority of the materials tested are generally Class 1A or 1B.

Table 4.4: Summary of PSD Classifications

Location	Depth (mbgl)	SHW Class	Laboratory Geological Description
TP1	1.50	1A or 1B	Brown silty slightly gravelly SAND
TP2	1.50	1A or 1B	Brown silty slightly gravelly SAND
TP6	1.00	2C	Brown silty gravelly SAND
CP01	1.20	2A & 2B	Brown silty SAND
CP01	2.00	2A & 2B	Brown slightly gravelly silty SAND
CP01	3.00	1A or 1B	Brown silty SAND
CP02	1.50	1A or 1B	Brown slightly gravelly silty SAND
CP02	2.45	1A or 1B	Brown slightly gravelly silty SAND
CP02	3.45	1A or 1B	Brown slightly gravelly silty SAND
CP03	1.20	1A or 1B	Brown slightly gravelly SAND
CP03	2.20	1A or 1B	Brown slightly gravelly silty SAND

Table 4.4: Summary of PSD Classifications

Location	Depth (mbgl)	SHW Class	Laboratory Geological Description
CP03	3.20	1A or 1B	Brown slightly gravelly silty SAND
CP04	1.50	1A or 1B	Brown clayey gravelly SAND with occasional cobbles
CP04	2.50	1A or 1B	Brown slightly clayey sandy GRAVEL
CP05	1.20	1A or 1B	Brown slightly gravelly silty SAND
CP05	2.20	1A or 1B	Brown slightly gravelly silty SAND
CP05	3.20	1A or 1B	Brown slightly gravelly SAND

4.4 Groundwater Strikes & Monitoring

4.4.1 Groundwater (GW) encountered during the investigation works and monitoring period are summarised in Table 4.5.

Table 4.5: Summary of GW Strikes and Monitoring

Location	GW Strike (mbgl)		GW Monitoring (mbgl)		GW fluctuation (m)	Comments
	Stike level	Level after 20mins	Minimum depth	Maximum depth		
TP01	1.20	-	N/A	N/A	N/A	Fast seepage
TP03	0.70	-				Fast seepage
TP08	0.40	-				Slow seepage
CP01	-	-	7.25	9.33	2.08	-
CP02	12.50	10.00	10.08	10.90	0.82	Fast seepage
CP03	-	-	6.73	9.40	2.67	-
CP04	-	-	8.59	8.93	0.34	-
CP05	7.53	7.53	8.84	9.29	0.45	Overnight seepage

4.5 Gas Monitoring

4.5.1 Gas monitoring standpipes were installed within LCP01, LCP02, LCP03, LCP04 and LCP05 with response zones targeting the superficial material in order to investigate the potential for the presence of potentially harmful ground gases. Monitoring comprised the measurement of atmospheric pressure, methane, carbon dioxide, oxygen, carbon monoxide, hydrogen sulphide and gas flow rate.

4.5.2 The results of the gas monitoring visits are attached at Appendix H and summarised in Table 4.6.

Table 4.6: Gas Monitoring Summary					
Determinand	LCP01	LCP02	LCP03	LCP04	LCP05
Methane (CH ₄) (%v/v)	0.00	0.00	0.00	0.00	0.00
Carbon Dioxide (CO ₂) (%v/v)	0.10-4.00	0.00-0.10	0.00-6.40	0.00-0.90	4.10-8.10
Oxygen (O ₂) (%v/v)	14.70-20.40	19.70-20.70	11.80-20.80	18.40-20.80	7.50-10.80
Carbon Monoxide (ppm)	0.00	0.00	0.00	0.00	0.00
Hydrogen Sulphide (ppm)	0.00	0.00	0.00	0.00	0.00
Flow (l/h)	0.00-2.10	0.00-11.80	0.00-0.10	0.00-0.40	0.00-0.40
Monitoring well					
Initial response zone (m)	1.00-21.00	10.00-17.00	1.00-21.00	1.00-23.00	2.40-15.30
Install depth during monitoring (m)	17.60-17.73	17.16-17.20	18.52-18.58	20.25-20.43	15.00-15.23
Length of well flooded (m)	8.4-010.48	6.30-7.12	9.12-11.79	11.32-11.79	5.71-6.16
Available response zone (m)	20.00	7.00	20.00	22.00	12.90
Notes: ND – Not detected in excess of the instrument's detection limit.					

5 CONTAMINATION RISK ASSESSMENT

5.1 Introduction

- 5.1.1 A primary purpose of ground investigations is to provide an assessment of the significance of likely ground contamination that may be encountered during the development of the site.
- 5.1.2 In the UK, contaminated land is regulated by the planning and development control system and the contaminated land regime set out in Part 2A of the Environmental Protection Act (EPA) 1990.
- 5.1.3 When considering an application for development, land contamination is a material consideration, and the local planning authority should satisfy itself that any contamination is properly assessed and adequately remediated, based on a suitable for use approach.
- 5.1.4 Environment Agency guidance “Land Contamination: Risk Management June 2019 (LCRM)” provides advice on the approach for the investigation and assessment of contamination on a site. This approach includes the production of a conceptual site model depicting the environmental processes that occur on and in the vicinity of the site and identifying the potential pollution linkages. The assessment of the significance of these pollution linkages can then be carried out through the risk assessment process.

5.2 Human Health

Screening Criteria

- 5.2.1 Laboratory contamination analysis has been undertaken on samples of NSDs and made ground taken from across the site. The significance of the recorded concentrations has been determined through a comparison with published Generic Assessment Criteria (GACs).
- 5.2.2 GACs are derived based on generic conceptual site models for a number of land-uses and making generic assumptions about receptor type and behaviour and building and soil properties.
- 5.2.3 The land uses included under the GAC include residential development, with and without the consumption of homegrown produce, allotments, commercial, public open space near residential and public open space. For this report the results of the laboratory contamination analysis have been compared against the GACs for a

commercial end land use.

- 5.2.4 There is no one source that publishes values for all contaminants and so the following sources have been used in the following order of preference:

Category 4 Screening Levels (C4SL)

- 5.2.5 In March 2014, the Department for Environment, Food and Rural Affairs published 6 Category 4 Screening Levels within their report "Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination" (SP1010). These GAC's are generated using the CLEA model, although the toxicological and exposure parameters have been modified so that the values represent "a more pragmatic approach to contaminated land risk assessment (albeit still strongly precautionary)." DEFRA state that the Category 4 Screening Levels will be used as generic screening criteria.

Suitable for Use Levels (S4UL)

- 5.2.6 Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) have published Suitable For Use Values (S4UL's) for 82 substances. These values, contained within the publication "LQM/CIEH S4ULs for Human Health Risk Assessment" (2015) replace the previous values contained within "Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)" dated 2009, and reflect the greater knowledge of relevant toxicology and further consideration of exposure scenarios.
- 5.2.7 Separate S4UL values have been published for three soil organic matter (SOM) contents (i.e. 1%, 2.5% and 6%). The average SOM for the site is 12.3%, however due to its variable nature (ranging from 2% to 19.4%) a value of 1% has been chosen for the initial screen as it is the most conservative approach.

5.3 Laboratory Contamination Analysis

- 5.3.1 The results of laboratory contamination analysis of the 9 No. samples obtained of the made ground and NSDs determine that after initial screening, there were no recorded exceedances of metals, TPHs incl. BTEX and MTBE or PAHs in any of the samples tested across the site, when compared against the GACs for a commercial end land use.
- 5.3.2 Four PCB EC7 congeners (101, 138, 153 and 180) were recorded above the laboratory limits of detection (LOD) in one sample of made ground taken at a depth of 0.2 m bgl in TP7. However, it is considered that the concentrations recorded are still very low, between 0.009 mg/kg and 0.028 mg/kg. All the other soil samples analysed recorded

concentrations of both PCB WHO12 and PCB EC7 congeners below the LODs. There are currently no UK screening levels (GAC) for the four congeners that were recorded above LOD due to a lack of toxicological data but in general these congeners are considered less toxic than the dioxin-like congeners included in the PCB WHO12 suite. In addition, PCB 118, considered to be the only dioxin-like PCB within the EC7 suite was recorded below the LOD in all the samples analysed. On the basis that the concentrations of the four congeners were low, no obvious source of PCBs has been identified on-site and PCB WHO12 congeners were below LODs in all samples, the risk is considered low.

- 5.3.3 Whilst elevated concentrations of the contaminants analysed were not recorded in the soil samples tested, given the variable nature of made ground the potential for it to contain contamination elsewhere cannot be discounted.

Asbestos

- 5.3.4 During the trial pitting exercise, some potential ACMs were observed as tiles found within the made ground. Asbestos identification was undertaken on nine soil samples taken from across the site and was recorded to be present in two of the nine samples tested.
- 5.3.5 The samples that contained asbestos were obtained from TP1@0.50mbgl and TP4@0.80mbgl (both within made ground). Asbestos quantification analysis was undertaken on these samples and identified 0.002 % loose chrysotile and amosite fibres within TP1 and <0.001 % loose chrysotile fibres within TP4. However, given the variable nature of made ground the potential for asbestos to be present elsewhere cannot be discounted.
- 5.3.6 As the site is proposed for a commercial development with no permanently occupied buildings, the made ground can likely remain on site below a suitably designed cover system and/or hardstanding.
- 5.3.7 Should visible ACMs be encountered during enabling works or construction works, works should stop, then this material should be isolated, sampled and analysed for asbestos and the risk assessment for asbestos should be updated accordingly.

Vapour Risk From Groundwater

- 5.3.8 Four groundwater samples were taken from boreholes CP02-CP05. These samples have been compared against the SoBRA Vapour GAC for commercial end use to assess

risks from groundwater sources to indoor air and subsequent vapour inhalation indoors.

- 5.3.9 None of the site-specific contaminants of concern were recorded at concentrations in excess of their detection limits/respective GAC.

Non-Aqueous Phase Liquid (NAPL) Risk

- 5.3.10 Soil and groundwater exposure models used in generating GACs do not account for the potential for NAPL to represent a source of risk to human health, principally due to the production of vapours. Whilst it is possible to calculate theoretical soil saturation limits, due to co-solubility effects, these are not an appropriate indicator of the presence of NAPL. In order to assess the presence of NAPL for petroleum hydrocarbons, an assessment criterion of 5,000 mg/kg for Total Petroleum Hydrocarbons has been applied based on professional experience. The following has been identified in relation to NAPL at the Site:

- No observations of NAPL were made within the soils observed during drilling.
- No concentrations of Total Petroleum Hydrocarbons in excess of 5,000 mg/kg were recorded.

- 5.3.11 No NAPL was measured during groundwater monitoring works. On this basis, it is unlikely that NAPL is present on Site.

5.4 Summary

- 5.4.1 Whilst the full assessment of the suitability of the made ground will need to be considered as part of the future detailed design, the results of this preliminary assessment indicate that the made ground backfill is suitable for re-use across the site. With the final land use being commercial it is likely that the material can remain in-situ. Further investigation into material will be required.

- 5.4.2 The sampled superficial deposits encountered below the made ground will be suitable for reuse, as samples tested show no signs of contamination, however further investigation into the material is advised.

5.5 Controlled Waters Risk Assessment

- 5.5.1 The underlying solid geology and superficial deposits are both designated as Secondary A Aquifers. There are no surface water features within the site development area.

- 5.5.2 There are two groundwater licenses within 500m of the site, both of which are located

within Pilsworth Landfill Site related to dewatering from sumps A and B. There are no surface water or potable water abstraction licences or Source Protection Zones within 500m of the site.

- 5.5.3 The ground investigation has proven the site to be generally underlain by sands which are underlain by clays and gravels, with a bedrock of the Mudstones proven to be present from 28.30mbgl (LCP01) to 28.50mbgl (LCP03).
- 5.5.4 Sand beds were encountered in all locations below the made ground, these are continuous across the site and consequently represent a potential migration pathway.
- 5.5.5 To assist in the assessment of the potential risk to controlled waters, groundwater samples were obtained from CP02, CP03, CP04 and CP05. It should be noted that the laboratory was unable to undertake the full suite for CP05 due to a limited volume of water available from the sample. As an initial screen of the significance of the recorded concentrations, the results of this testing have been compared to Environmental Quality Standards (EQS) derived from The River Basin Districts Typology, Standards and the Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2015. As there are no potable water abstractions with 1 km of the site, the contaminants have not been screened against the UK Drinking Water Standards (DWS).
- 5.5.6 The results received from the laboratory testing returned results lower than the laboratory detection limit, therefore there were no recorded exceedances in the samples tested.
- 5.5.7 Given the result of the desk based researches, ground investigation data and laboratory testing, it is considered that the development represents a low risk to controlled waters. In addition, it is likely that as part of the proposed development, hardstanding will be installed with associated drainage systems which will, consequently, reduce water infiltrating through the soil and production of leachate and further lowering the risk to controlled waters.

Groundwater Flow

- 5.5.8 Based on the monitoring of water strikes during the drilling of the BHs and TPs, it appears that only perched groundwater has been encountered at the site within the made ground.
- 5.5.9 The groundwater monitoring has demonstrated the groundwater level to be relatively deep found with the shallowest water found within CP03 at 6.73mbgl.

5.6 Preliminary Ground Gas Risk Assessment

- 5.6.1 Gas monitoring wells were installed in all five LCP boreholes, with ground gas monitoring undertaken on 6 occasions between 19 March 2024 and 23 April 2024. Ground gases were monitored in accordance with CIRIA C665 with visits taking place across a range of atmospheric pressure dynamics (957 – 1014mb).
- 5.6.2 Gas monitoring boreholes were installed within five of the LCP BHs. No methane concentrations and only positive gas flows were recorded above the instrument level of detection of 0.1 % and 0.1l/h respectively. Carbon dioxide was recorded in a maximum concentration of 8.1%.
- 5.6.3 In order to assess the potential risk posed by the recorded gas concentrations at the site as an initial screen the methodology presented within CIRIA C665 “Assessing risk posed by hazardous ground gases to buildings 2007” has been used.
- 5.6.4 BS8485 and CIRIA C665 require the calculation of a Gas Screening Value (GSV) (Litres of gas per hour) using the formula below:

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

- 5.6.5 This calculation has been undertaken for carbon dioxide using the highest recorded concentration, therefore adapting the worst-case volume. A maximum steady flow of 11.8l/hr was measured during the monitoring process. This seems to be an outlier but was recorded in the borehole which was observed to have the highest recorded carbon dioxide concentrations.

$$\text{Carbon Dioxide GSV} = 8.1 \% / 100 \% \times 11.8 \text{ l/hr} = 0.9558 \text{ l/hr}$$

- 5.6.6 A preliminary conservative GSV of 0.9558 l/hr has been calculated from data obtained during the monitoring programme. This places the site in a Characteristic Situation (CS) 3 i.e., a moderate risk classification where 2 No. special gas protection measures are considered necessary. This assessment is based off the worst case scenario. More monitoring may be required to lower the risk and risk classification.
- 5.6.7 The ground gas regime at the Site has been classified as CS3 in accordance with the CIRIA guidance and it is recommended that a CS3 situation is assumed for design purposes. BS:8485 provides a scoring system to determine the appropriate protection measures for a proposed development in accordance with the identified ground gas regime. Table 3 of BS:8485 summarises typical UK building types, which for this development will comprise Type D (industrial). Table 4 details the points required for

the Characteristic Situation, which for CS3 is 2.5. This can be achieved by a combination of the following:

- Basement floor and walls conforming to BS 8102:2009, Grade 3 waterproofing (Table 5); and
- Passive subfloor dispersal layer (Table 6).

6 GEOTECHNICAL ASSESSMENT

6.1 General

- 6.1.1 The ground investigation comprised the excavation of TPs, LCP and ROH BHs to investigate the distribution of the soil types present at the site and to facilitate in-situ and laboratory geotechnical testing. The on-site and laboratory geotechnical testing was conducted to determine general soil classification and strength parameters to enable preliminary advice and recommendations to be given regarding the choice of foundation types and material re-use on site.
- 6.1.2 The in-situ geotechnical test results are recorded on the LCP logs within Appendix E. The laboratory geotechnical testing detailed in Section 4 of this report is contained within Appendix G.

6.2 Foundations

- 6.2.1 Various foundation options have been considered for the site. The most appropriate solution for the development will depend on the final layout and levels, anticipated structural loadings and the tolerance of the proposed development to differential settlement.
- 6.2.2 The selection of foundation types will need to consider the wider development proposals and take into account the potential impact of any proposed engineering works.
- 6.2.3 It is expected that the final design of foundation solutions would require additional targeted ground investigation.
- 6.2.4 A discussion of possible foundation solutions based on the result of the ground investigation is below:

Shallow Strip / Pad Foundations

- 6.2.5 The ground investigation found extensive deposits of made ground present beneath the site to a maximum observed depth of 1.30mbgl. Beneath the made ground, the site is underlain by a dense to very dense sands. These deposits range in N-values of between 9 and 50/refusal. However, generally, the N-values are greater than 20.
- 6.2.6 Generally, areas of made ground are not suitable for shallow foundation design due to inherent variability of how made ground acts under loading and therefore we would suggest the strips / pads should be founded within the sand deposits beneath the made ground.

Piled Foundations

- 6.2.7 It is shown on client drawing 'Proposed MRF Location Option 1' that the MRF will contain a variety of machinery. At the time of writing, the loading imposed by this machinery is not known and therefore there is a possibility that some piling may be required beneath the concrete slab of the MRF to mitigate against any settlement caused by this machinery.
- 6.2.8 A piled foundation transfers structural loads through weaker near surface deposits and made ground to deeper more competent ground. The different piling options are discussed below:
- **Driven Piles:** Conventional driven piling, concrete or hollow steel, uses the methodology which will produce the most vibration. It produces vibration throughout the drive, on every hammer blow. If driven piling is to be considered as the most favourable option, reducing the impact of the hammer will reduce the severity of the vibration in the ground. This will increase the frequency of the hammer blows and extend the amount of time required for piling each plot. Driven pre-cast concrete piles are likely to be the most cost-effective solution, however they will produce the most vibration and, if proposed, will require an assessment of potential obstructions such as large cobbles encountered during the drilling.
 - **Bored Piles:** Bored piles should not create significant vibration provided they can be installed without the use of temporary driven casing. There are various forms of bored pile available, such as bored displacement and continuous flight auger (CFA) piles. Such piles are generally more costly than driven piles and most bored pile systems produce arising's that will either require incorporation into earthworks or off-site disposal.
- 6.2.9 Consideration should be given during the design of any piling, should this be required on site, to the potential for negative skin friction associated with the presence of the made ground deposits on site. Differential settlement between the concrete slab and shallow strip/pad foundations.
- 6.2.10 All foundations should be designed by a suitably qualified engineer to meet current design standards.

6.3 Heave Precautions

- 6.3.1 Heave precautions are generally not required in granular soils as they are less

susceptible to the shrinking and swelling that causes heave. However, it was proven within the in-situ falling head tests, that the NSDs tested, proved low permeability. Notwithstanding this, the investigation logs and laboratory PSD testing proved the material to be granular and contain insufficient quantities of material with shrink / swell potential and therefore not susceptible to heave.

6.3.2 However, further assessment will be required to determine the heave precaution requirements in advance of construction by reference to the final building layout and confirmed levels, suitable standards and an appropriately detailed Arboricultural Survey.

6.3.3 Where any proposed structure is to be constructed within the influence of existing and/or proposed trees, heave precautions may be required.

6.4 Dewatering

6.4.1 GW strikes were recorded in three TP locations (TP01@1.20 mbgl, TP03@0.70 mbgl and TP08@0.40 mbgl) and two LCP BHs (CP02@12.50 mbgl and CP05@7.53 mbgl) during the investigation works. Generally, the GW strikes were recorded as fast seepages of water. Based upon the GW conditions observed during the ground investigation and monitoring period, it is likely that GW will present a constraint during construction for foundations and service excavation.

6.5 Stability

6.5.1 The NSDs were generally stable throughout excavation aside from TP03, TP06 and TP07 which all collapsed at 3.00 mbgl. Therefore, bearing in mind the consistent characteristics of the near surface NSDs, excavation stability is unlikely to be a major constraint during construction, however when excavating to depths of 3.00 mbgl, it would be prudent to either install temporary trench support or batter back any excavation sides. This situation is likely to be exacerbated by water inflows.

6.5.2 Temporary trench support, or battering of excavation sides, is likely to be required for all excavations that are to be left open for any length of time.

6.5.3 A risk assessment of the stability of any open excavation should be undertaken by a competent person and appropriate measures adopted to ensure safe working practices in and around open excavations.

6.6 Buildings and Infrastructure - Sulphate Content (Buried Concrete)

6.6.1 Sulphates and acids within the ground can be destructive to concrete and result in

expansion and / or softening. The laboratory contamination analysis along with the soil type and water levels have been used to assess the potential for chemical attack on buried concrete in new structures on the site.

- 6.6.2 Laboratory testing has been conducted on soil samples recovered from the various strata encountered across the site to determine the Design Sulphate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification for proposed buried concrete in accordance with BRE Special Digest 1 :2005 3rd Edition "Concrete in Aggressive Ground" document. The laboratory test results are provided in Appendix G.
- 6.6.3 During the intrusive works, groundwater was encountered at various levels across the site and found to vary during the groundwater monitoring period. Therefore, the assessment has been undertaken accounting for the presence of mobile groundwater.
- 6.6.4 The sampling and testing of the soil recovered from site has recorded the following;
- The soils pH levels across the site range from pH 7.28 to pH 9.26; and
 - Water soluble sulphate levels range from 20mg/l to 16,000mg/l.
- 6.6.5 Based upon the use of the methodology set out in BRE Special Digest 1:2005 3rd Edition "Concrete in Aggressive Ground", the design sulphate class for this site assuming mobile groundwater varies from DS1 (TP6 and TP7), DS2 (TP2, TP7 and TP8) and DS3 (TP1, TP3, and TP4) the aggressive chemical environment for concrete (ACEC) classification for the site AC1 (DS1 locations), AC-2 (DS2 location) and AC3 (DS3 locations). Therefore, as a worst-case scenario, the design sulphate class for this site is DS-3 and the ACEC classification for the site AC-3. However, it should be noted that further consideration should be made during the detailed design stage once the location and types of structures to be constructed have been confirmed.

6.7 Engineering Soil Suitability for Re-use

- 6.7.1 The majority of the material taken from site for laboratory geotechnical testing was generally classified as General Granular Fill aside from CP01@1.20 mbgl and 2.00 mbgl and TP06 which were General Cohesive Fill according to the SHW Table 6/2. On that basis the majority of the materials across the site should be geotechnically suitable for re-use in accordance with an accepted earthworks specification such as the current version of the SHW.

6.8 Additional Comments

- 6.8.1 It is recommended that during the detailed design and future development works, further targeted GI works should be undertaken by the developer specifically relating to foundation design on site.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

- 7.1.1 The findings of the ground investigation are unlikely to preclude the proposed development of the site. The key conclusions and recommendations relating to the development of the site are summarised below.

7.2 Geotechnical Assessment

Foundations

- 7.2.1 Due to the unknown final loadings of the building, two possible founding solutions have been considered.
- 7.2.2 It is likely that shallow strip foundations would be suitable within the dense sands but should there be significant line loading imposed by the plant and machinery permanently based in the building, piled foundations may be required.
- 7.2.3 The final foundation solution will be subject to further investigation and confirmation of final design loadings. All foundations should be designed by a suitably qualified engineer to meet current design standards.

Heave Precautions

- 7.2.4 The NSDs on site at shallow depth were proven to be granular in the investigation logs and laboratory PSD testing, and therefore are not susceptible to heave. However, further assessment will be required to determine the heave precaution requirements in advance of construction by reference to the final building layout and confirmed levels, suitable standards and an appropriately detailed Arboriculturally Survey.

Dewatering

- 7.2.5 Based upon the GW conditions observed during the ground investigation and monitoring period, it is likely that GW will present a constraint during construction for foundation and service excavation.

Stability

Pits generally remained stable during trial pitting investigation with it becoming unstable at depths of around 3.00mbgl. It would be prudent to either install temporary trench support or batter back any excavation sides. This situation is likely to be exacerbated by water inflows.

Buildings and Infrastructure

- 7.2.6 Based on guidance on BRE Special Digest 1:2005 Third Edition, the soils can be classified as Design Sulphate Class for DS-3 and aggressive chemical environment for concrete (ACEC) class AC-3 as worst-case scenario based on the testing.

Mining

- 7.2.7 Rotary open-hole boreholes reported smooth and steady drilling through largely grey mudstone with no evidence of coal seams of a significant thickness, significant flush loss, voids or broken ground reported throughout drilling. There was no evidence that the Arley seam was present during the investigation. The risk to the site of unrecorded shallow workings is therefore considered to be low.

Re-use of Site-won Materials and Materials Management Plan

- 7.2.8 The majority of the material taken from site for laboratory geotechnical testing was classified as Class 1A & 1B. On that basis the majority of the materials across the site should be geotechnically suitable for re-use in accordance with SHW.

7.3 Contamination Assessment

- 7.3.1 The results of the ground investigation and risk assessment suggest that the overall risk associated with soil contamination is low. The results of this investigation suggest that the made ground is suitable to remain at the surface following the commercial development. PCBs were detected above the detection limit in one of samples but not in quantities that would be of concern to the future development.
- 7.3.2 Made ground was encountered across the entire site, and whilst it found to be generally free from contamination, given the variable nature of the made ground the potential for it to contain contamination elsewhere cannot be discounted. However, as the site is proposed for a commercial development with no permanently occupied buildings, the made ground can likely remain on site below a suitably designed cover system and/or hardstanding.
- 7.3.3 Asbestos was encountered within small quantity within 2 samples. Although found in small quantities, the variability of the made ground indicates there is a possibility more material could be present. Care should be taken when undertaking further construction works.

Vapour Risk From Groundwater

- 7.3.4 None of the site-specific contaminants of concern were recorded at concentrations in

excess of their detection limits/respective GAC within any of the water samples taken.

Non-Aqueous Phase Liquid (NAPL) Risk

- 7.3.5 No NAPL was observed during the groundwater monitoring or the ground investigation.

Controlled Waters Risk Assessment

- 7.3.6 There were no exceedances detected within the water samples taken from site. In addition, it is likely that as part of the proposed development, hardstanding will be installed with associated drainage systems which will, consequently, reduce water infiltrating through the soil and production of leachate and further lowering the risk to controlled waters. Therefore, the risk to controlled waters is considered to be low.

Preliminary Gas Risk Assessment

- 7.3.7 The preliminary gas risk assessment indicates that the site lies within a CS 3 i.e., a moderate risk classification where 2 No. special gas protection measures are considered necessary. This assessment is based on the limited assessment undertaken and further consideration of the risks should be made once the final location and nature of the development is known.

7.4 Additional Comments

- 7.4.1 As with any GI involving discrete sampling, test results will only be representative of the points sampled. If suspect material is encountered during either any enabling works or construction works then this material should be isolated and further investigation undertaken to determine the risk posed by these materials and appropriate method of disposal etc.

7.5 Recommendations

- 7.5.1 Further site work is recommended following receipt of final building layout and loadings should piling be required and to provide additional information to facilitate the final design works.
- 7.5.2 Consideration should be taken during the final design works, ensuring that any civils, structural or landscape aspects of the development do cause detrimental effects on the geotechnical aspects of the site.
- 7.5.3 The falling head tests undertaken during the site works concluded that at the points of investigation there were relatively low permeabilities records, contrary to what

would be expected from a granular material. It is recommended that this is considered within the final drainage design works, and possibly to undertake further investigation should attenuation be required for surface water control.

APPENDICES

APPENDIX A
Proposed Development Plan

APPENDIX B
Phase I Desk Study Report

APPENDIX C
Wardell Armstrong LLP Trial Pit Photos

APPENDIX D
Wardell Armstrong LLP Site Investigation Logs

APPENDIX E
Geotron (UK) Ltd Borehole Logs

APPENDIX F
Laboratory Contamination Testing Results

APPENDIX G
Laboratory Geotechnical Testing Results

APPENDIX H
Gas and Groundwater Monitoring Results

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