waterman	Internal angle of friction
Project ID: **WIE17469**	Project Title: **Ground Investigation Report**
Client: **Gardiner and Theobald LLP**	Location: **Cambridge**

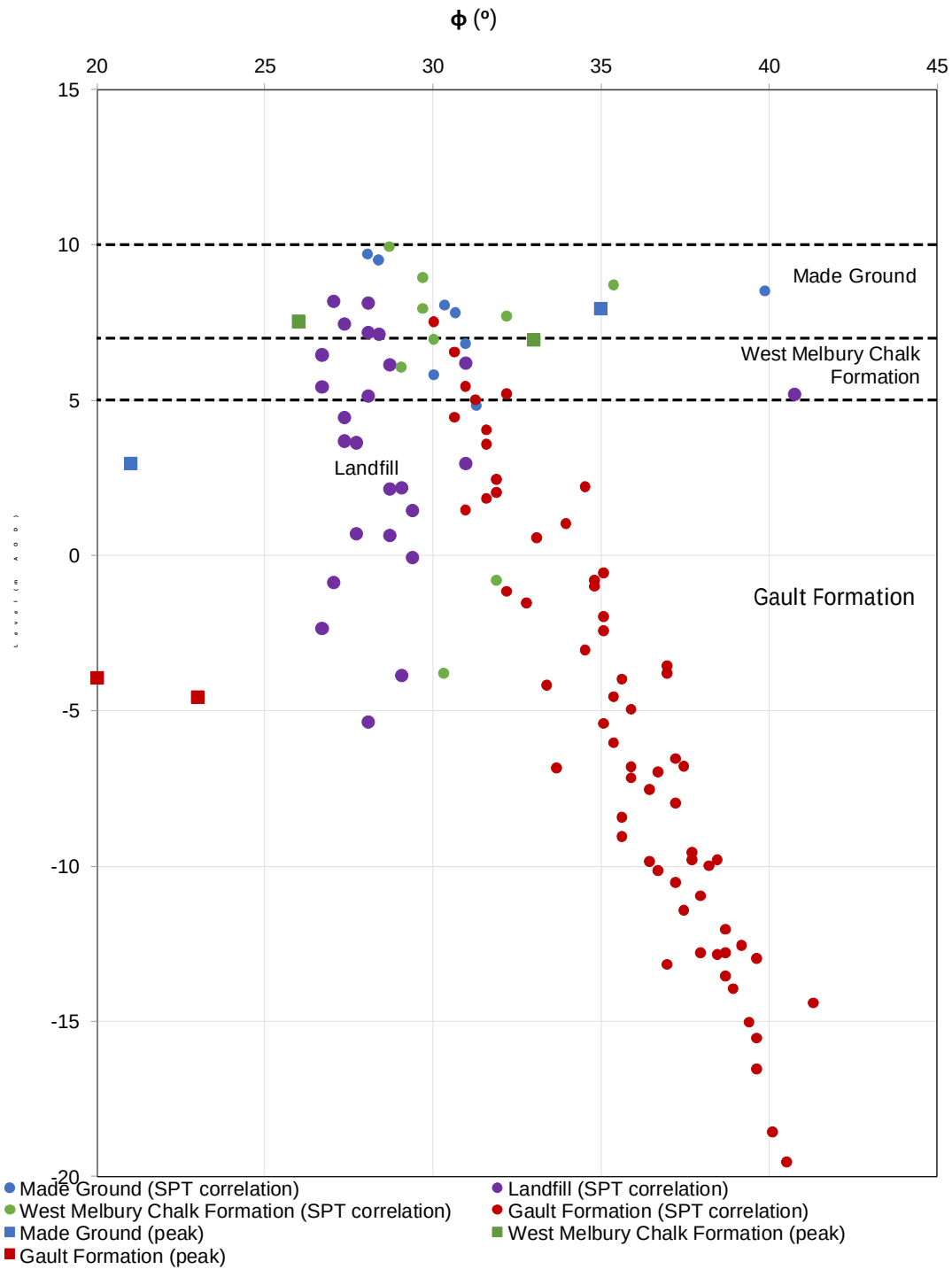


Figure B1-4: **Angle of shearing resistance versus level (all strata) for 230 NMR and CRP**

waterman	Unconfined Compressive Strength
Project ID: **WIE17469**	Project Title: **Ground Investigation Report**
Client: **Gardiner and Theobald LLP**	Location: **Cambridge**

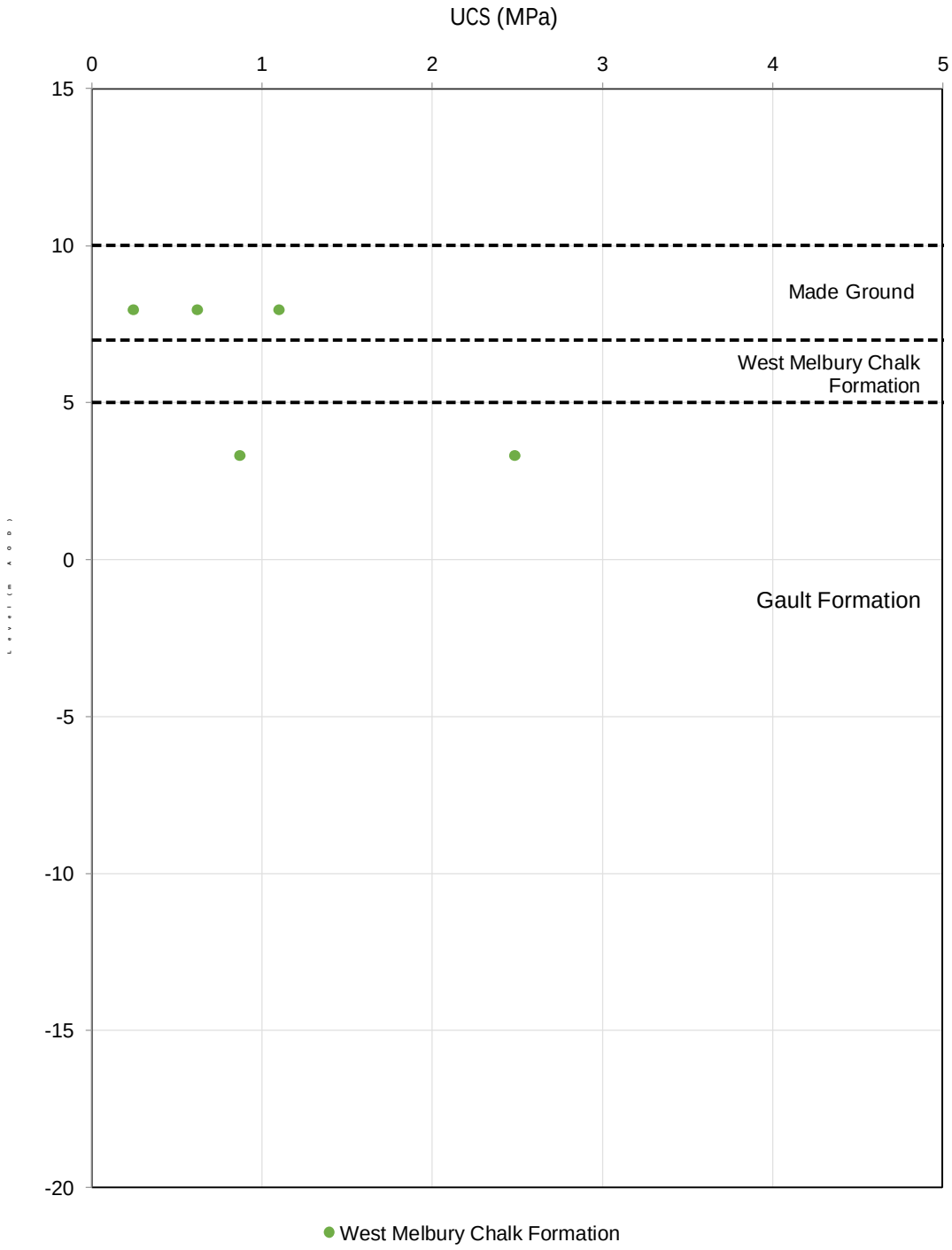


Figure B1-5: **Unconfined compressive strength versus level for 230 NMR and CRP**

waterman

A Line Plot

Project ID:	**WIE17469**	Project Title:	**Ground Investigation Report**
Client:	**Gardiner and Theobald LLP**	Location:	**Cambridge**

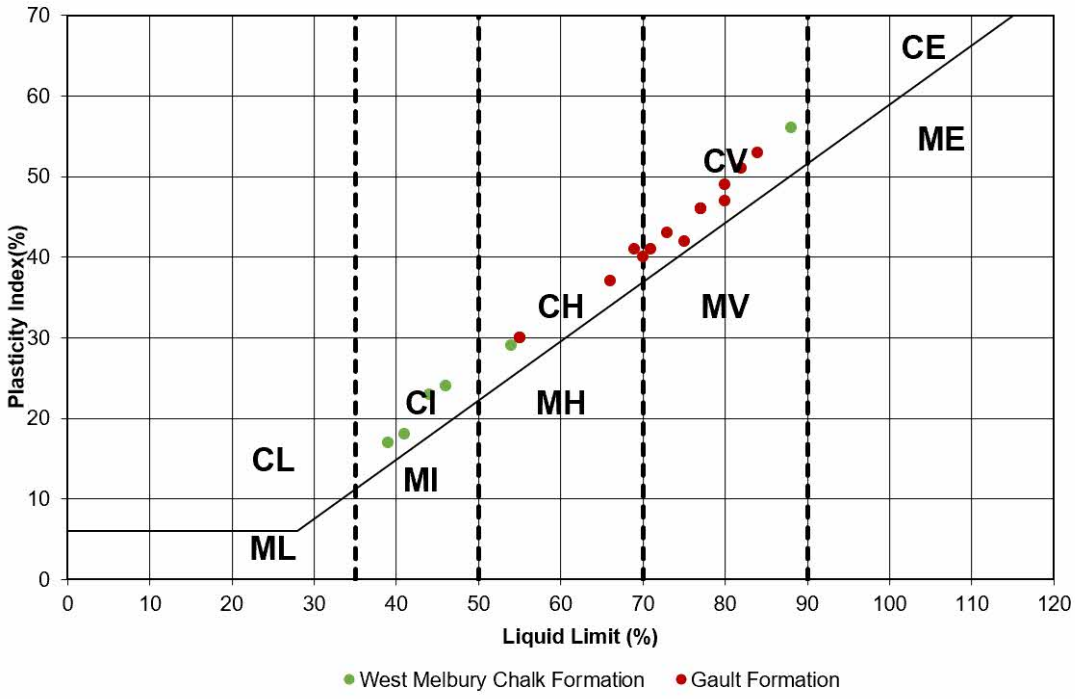


Figure B1-6: A-Line plot (cohesive) for 230 NMR and CRP

B2. Beehive Retail Centre

waterman	SPT N Value
Project ID: **WIE17469**	Project Title: **Ground Investigation Report**
Client: **Gardiner and Theobald LLP**	Location: **Cambridge**

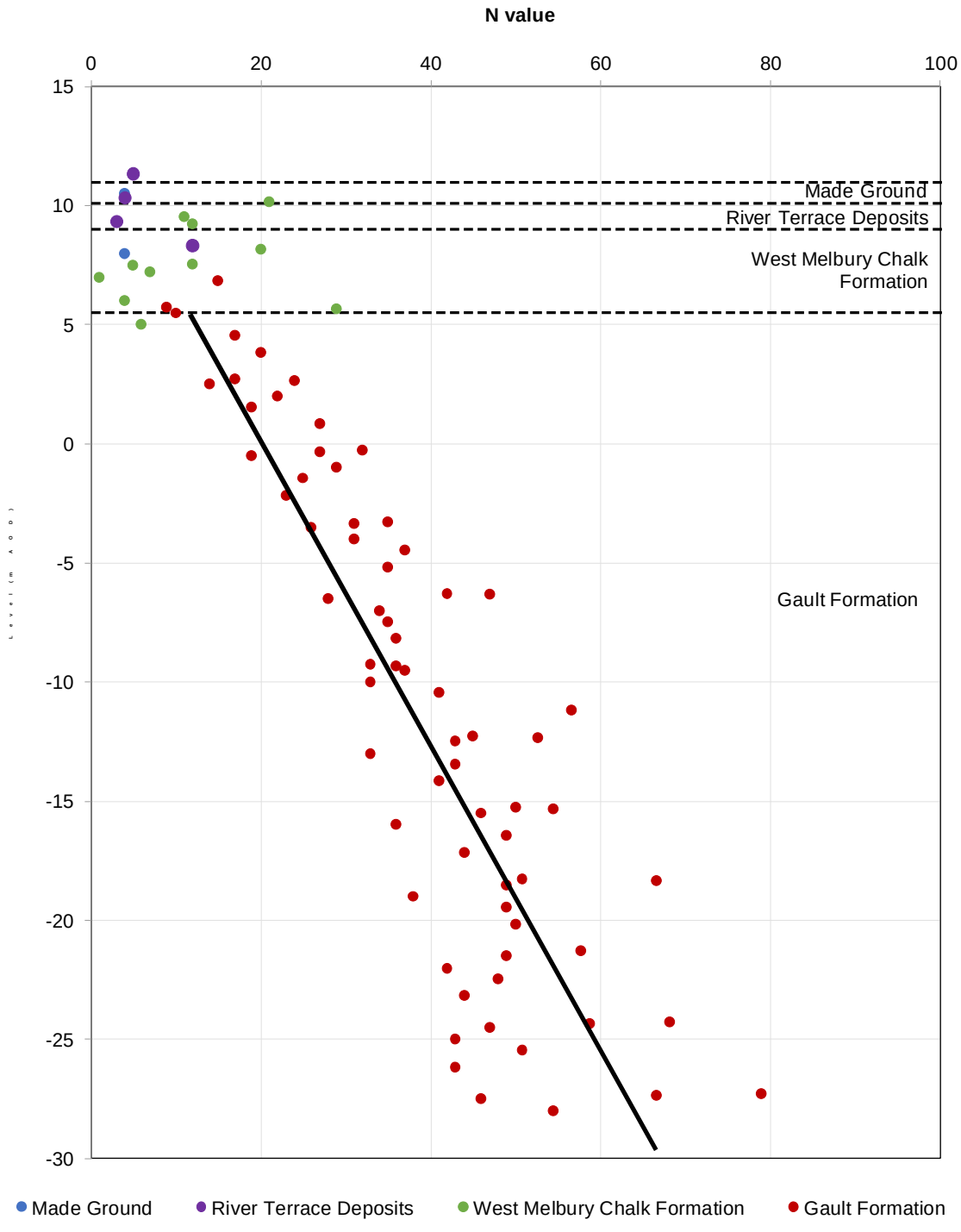


Figure B2-1: **SPT value versus level (all strata) for Beehive Retail Centre**

waterman	Unit Weight
Project ID: **WIE17469**	Project Title: **Ground Investigation Report**
Client: **Gardiner and Theobald LLP**	Location: **Cambridge**

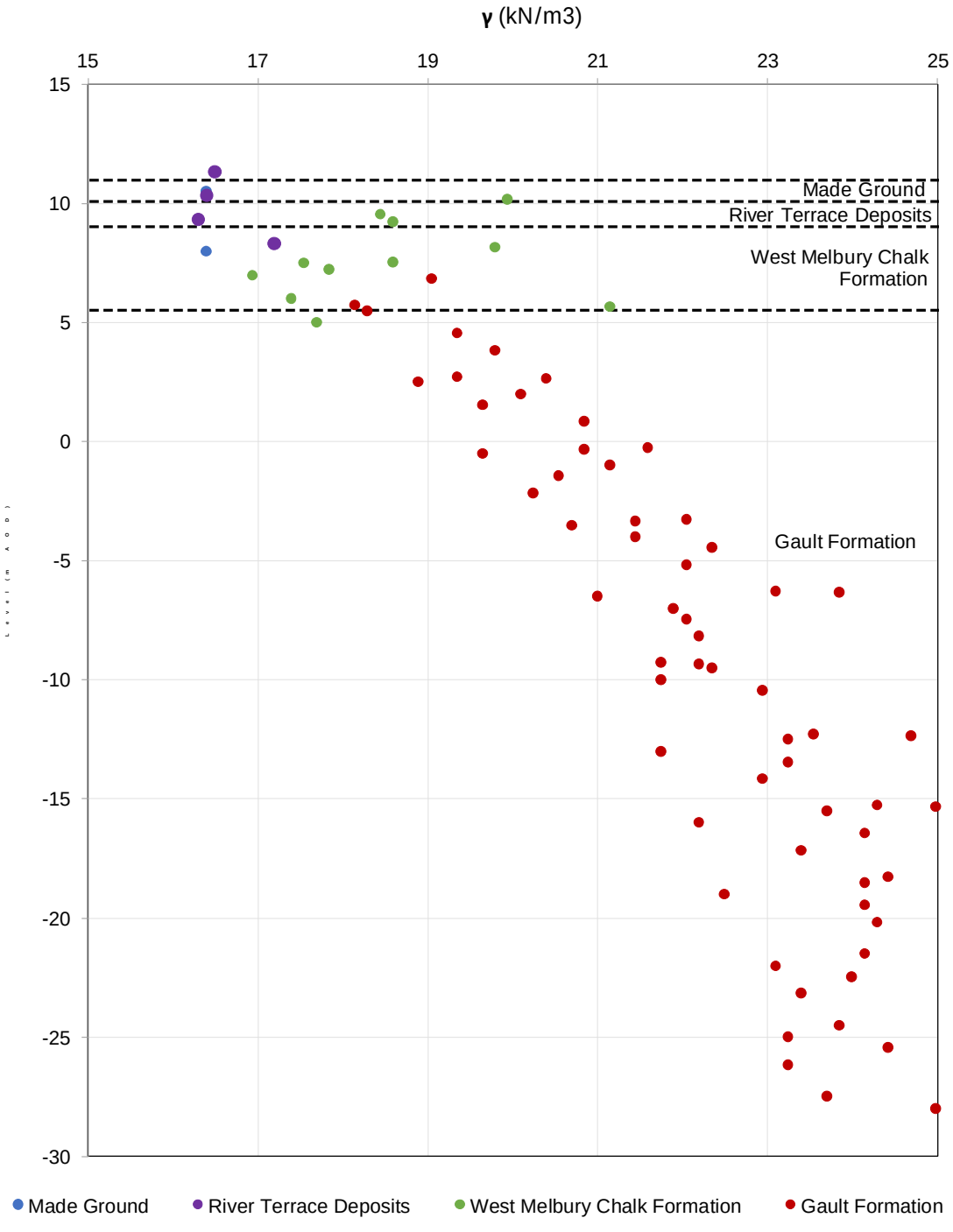


Figure B2-2: **Unit weight versus level (all strata) for Beehive Retail Centre**

waterman	Undrained Shear Strength
Project ID: **WIE17469**	Project Title: **Ground Investigation Report**
Client: **Gardiner and Theobald LLP**	Location: **Cambridge**

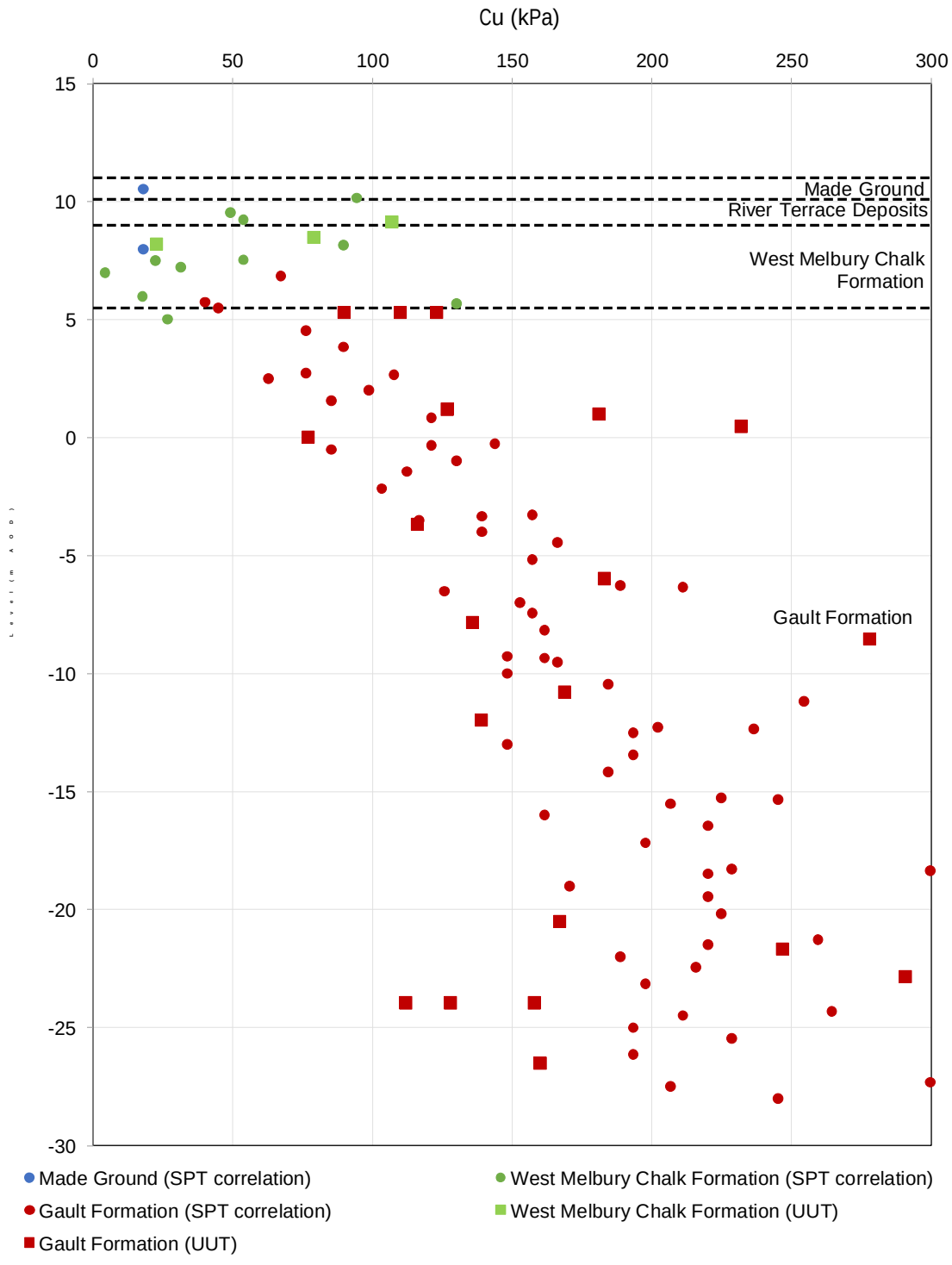


Figure B2-3: **Undrained shear strength versus level (cohesive strata) for Beehive Retail Centre**

waterman	Internal angle of friction

Project ID:	**WIE17469**	Project Title:	**Ground Investigation Report**
Client:	**Gardiner and Theobald LLP**	Location:	**Cambridge**

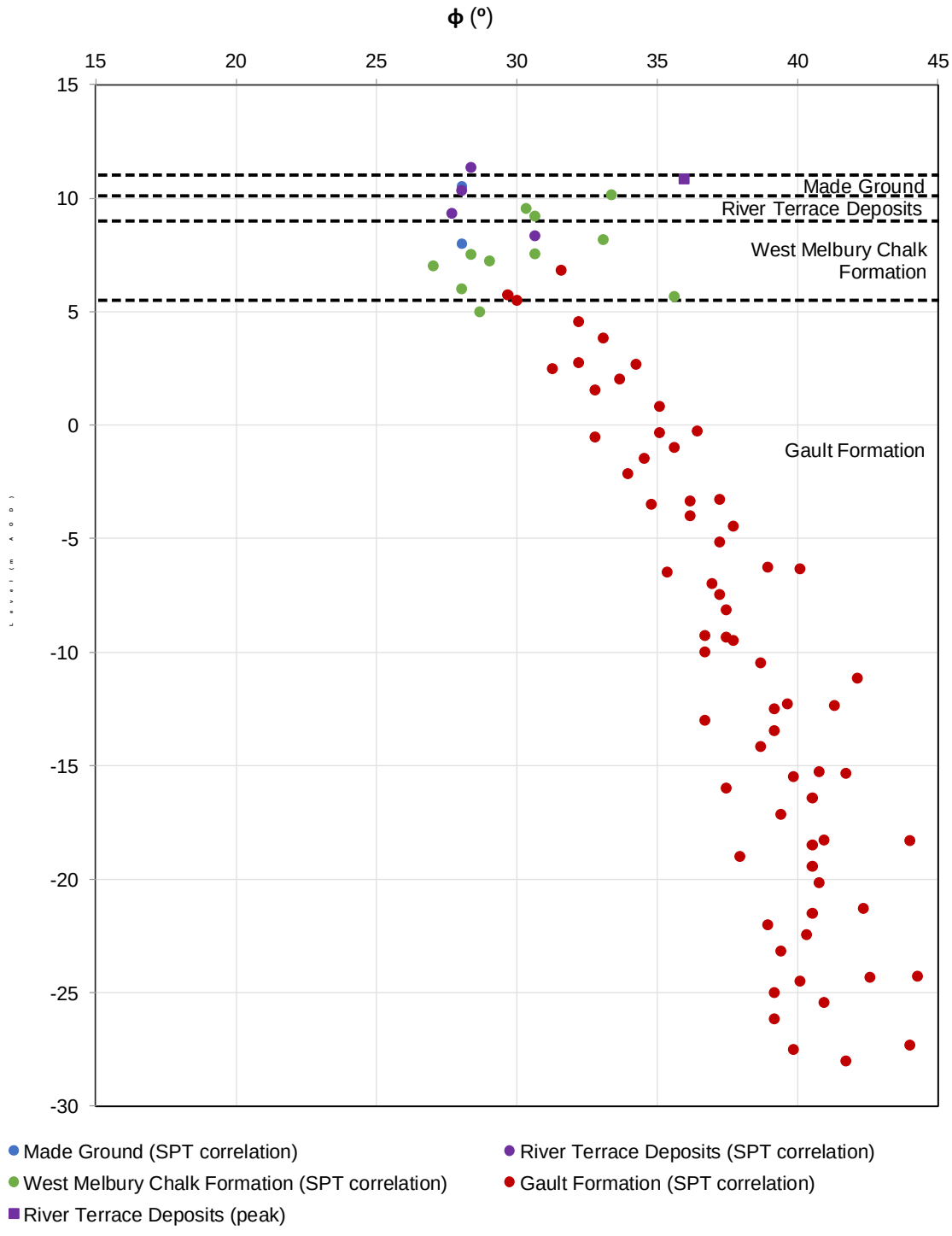


Figure B2-4: **Angle of shearing resistance versus level (all strata) for Beehive Retail Centre**

waterman	Unconfined Compressive Strength

Project ID:	**WIE17469**	Project Title:	**Ground Investigation Report**
Client:	**Gardiner and Theobald LLP**	Location:	**Cambridge**

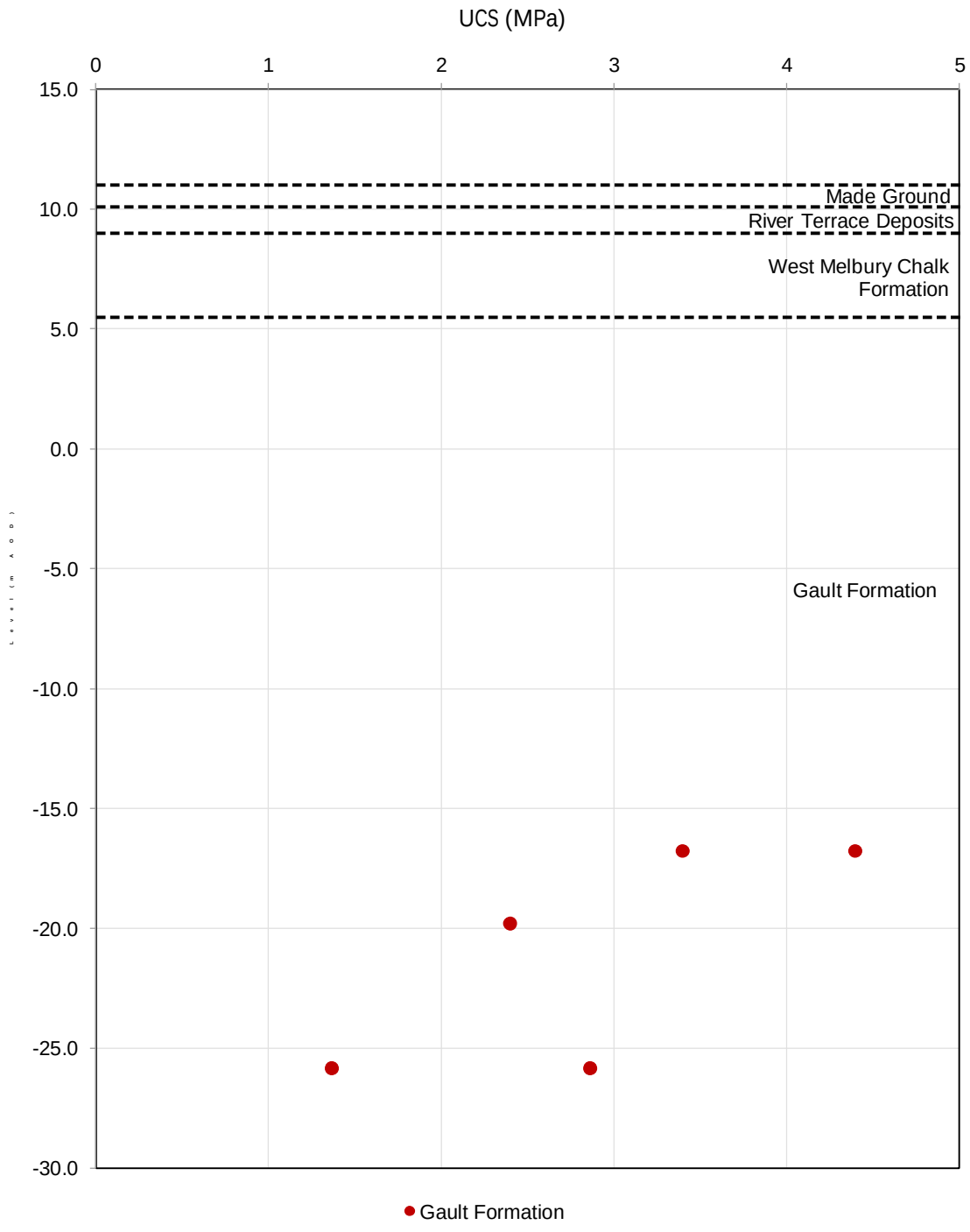


Figure B2-5: **Undrained shear strength versus level for Beehive Retail Centre**

waterman

A Line Plot

Project ID:	**WIE17469**	Project Title:	**Ground Investigation Report**
Client:	**Gardiner and Theobald LLP**	Location:	**Cambridge**

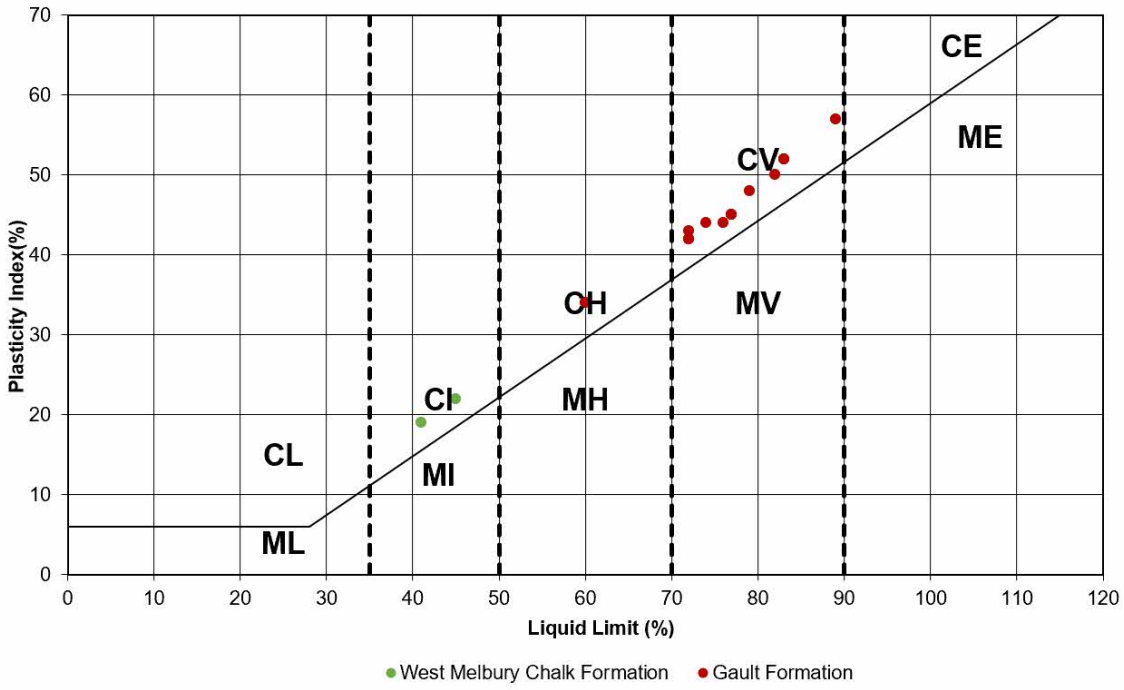
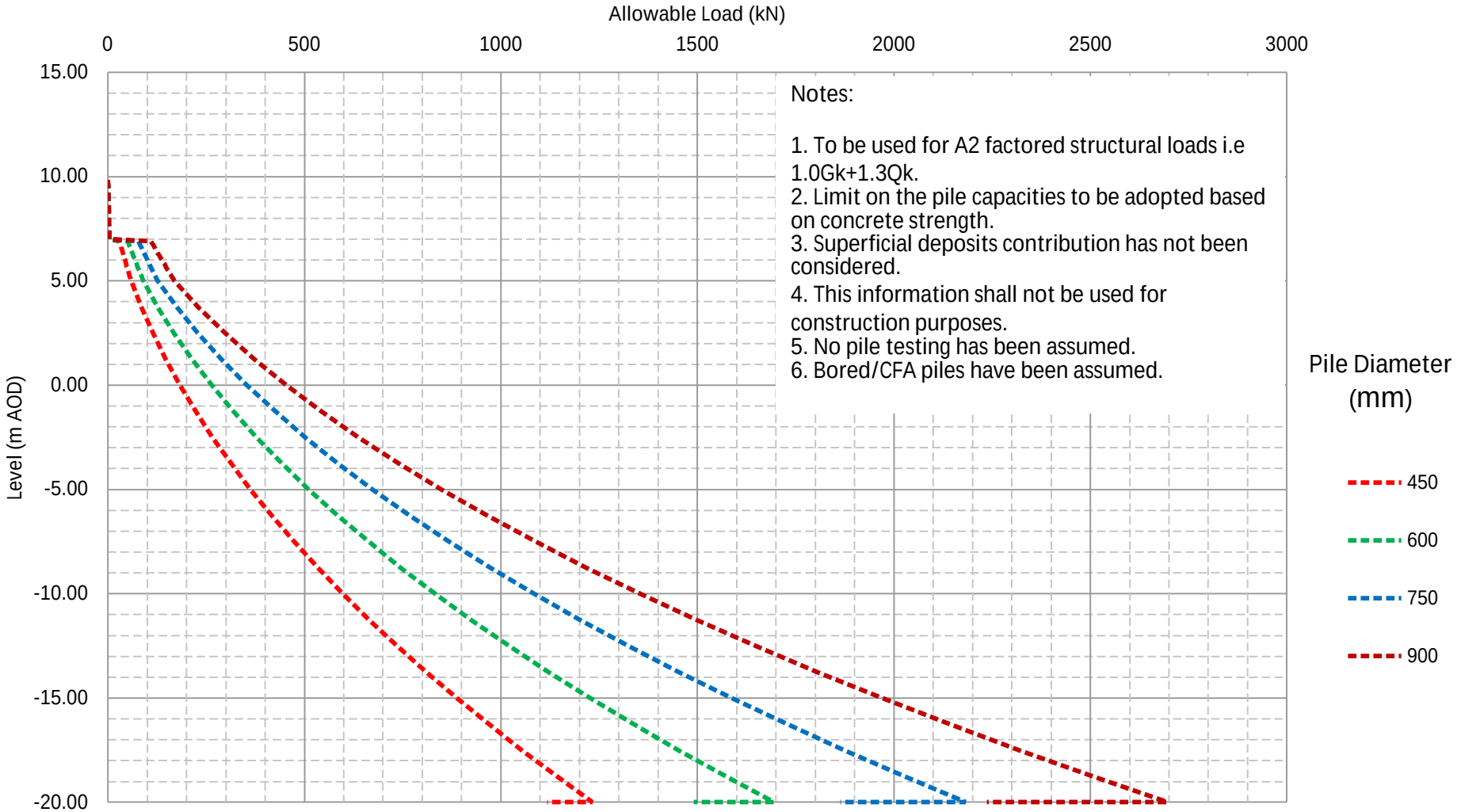


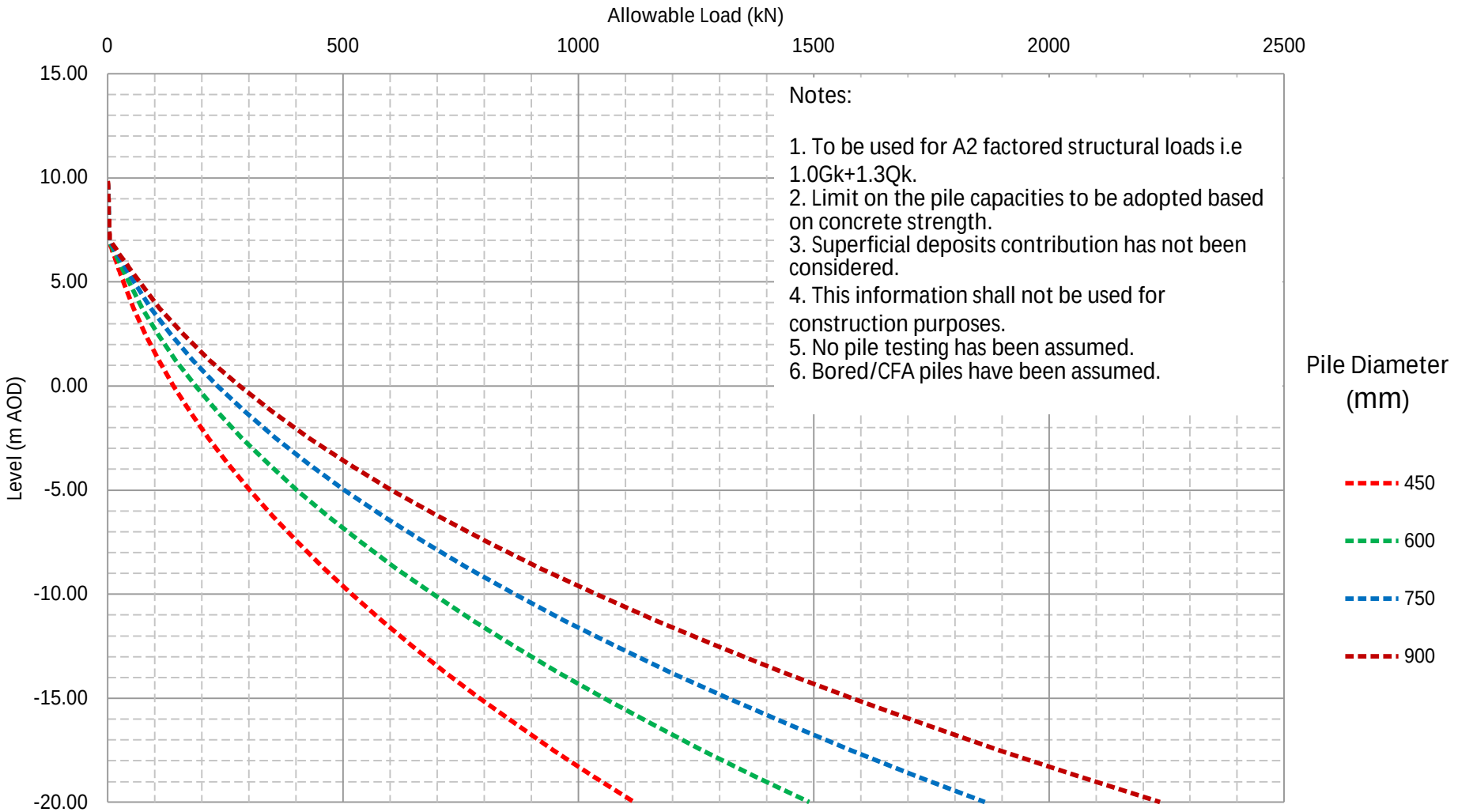
Figure B2-6: A-Line plot (cohesive) for Beehive Retail Centre

C. Pile Allowable Load Charts

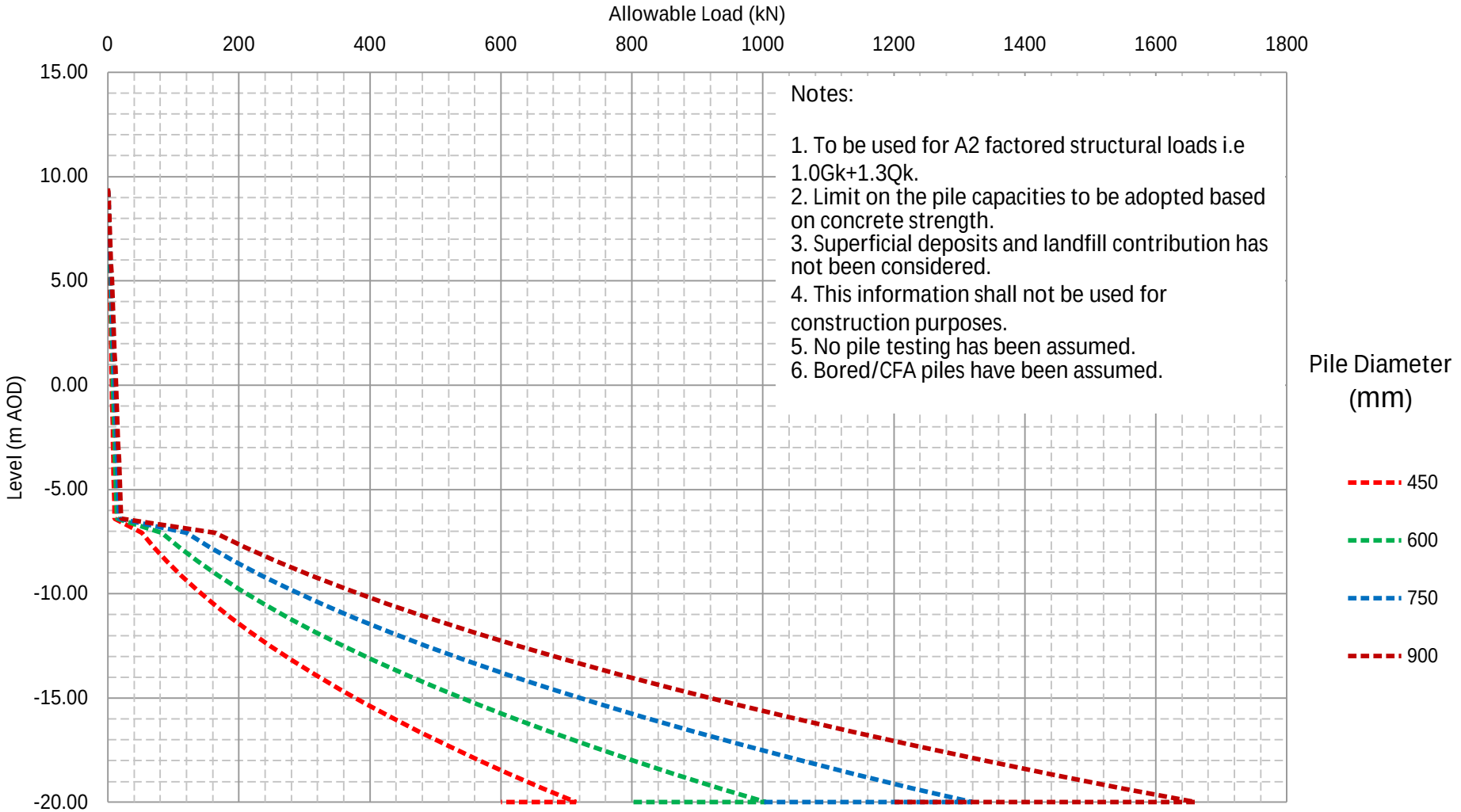
Ground Model 1 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Compression



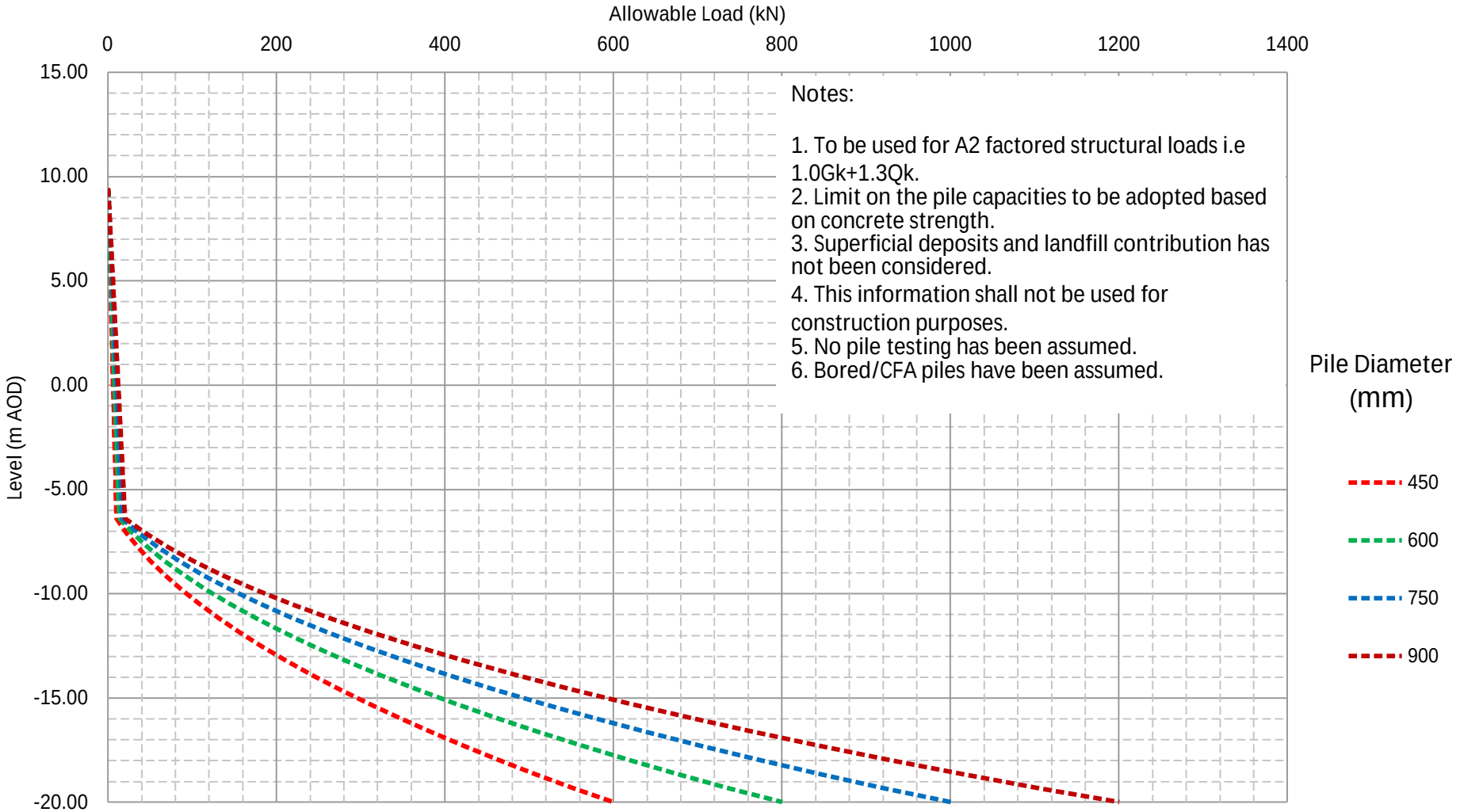
Ground Model 1 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Tension



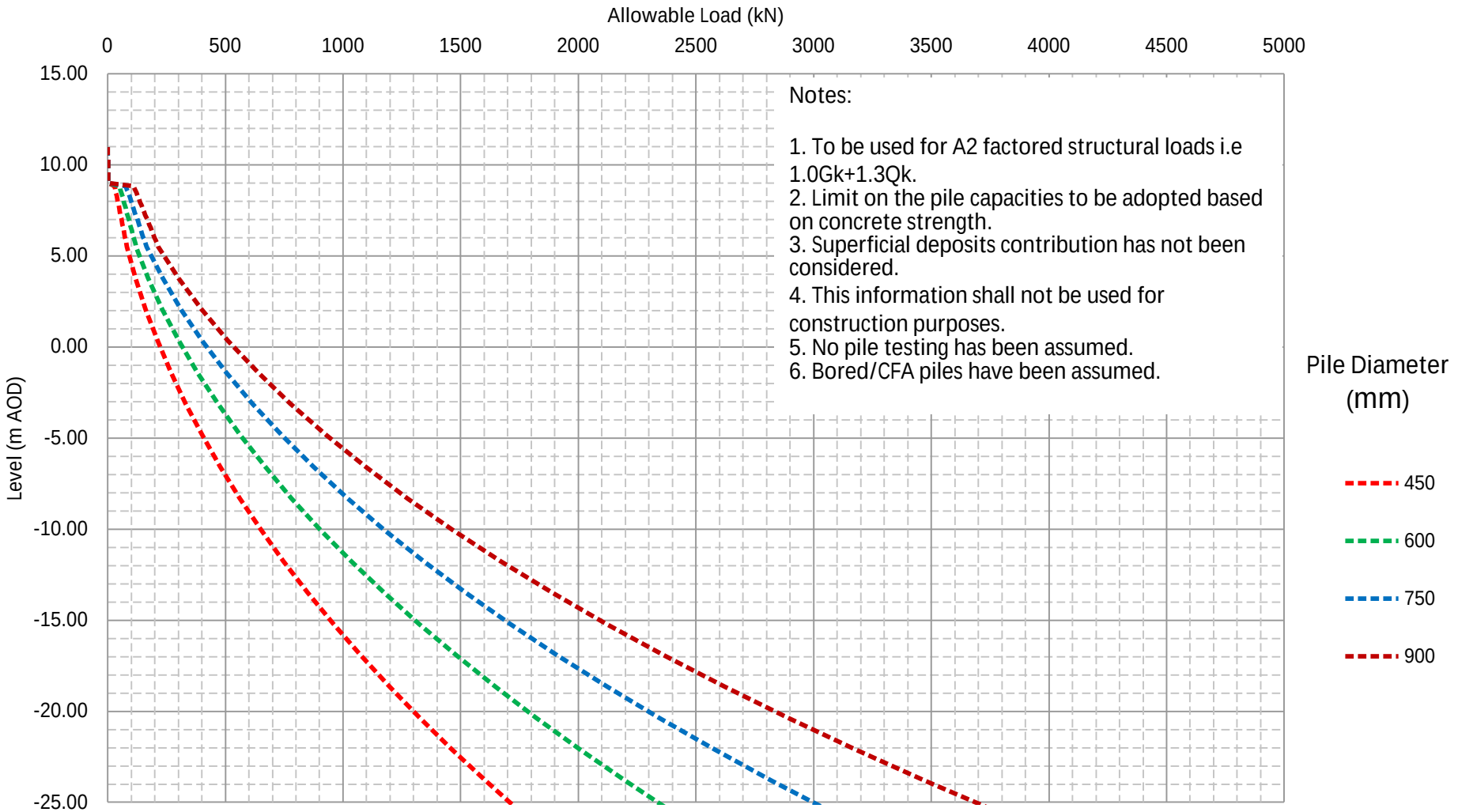
Ground Model 2 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Compression



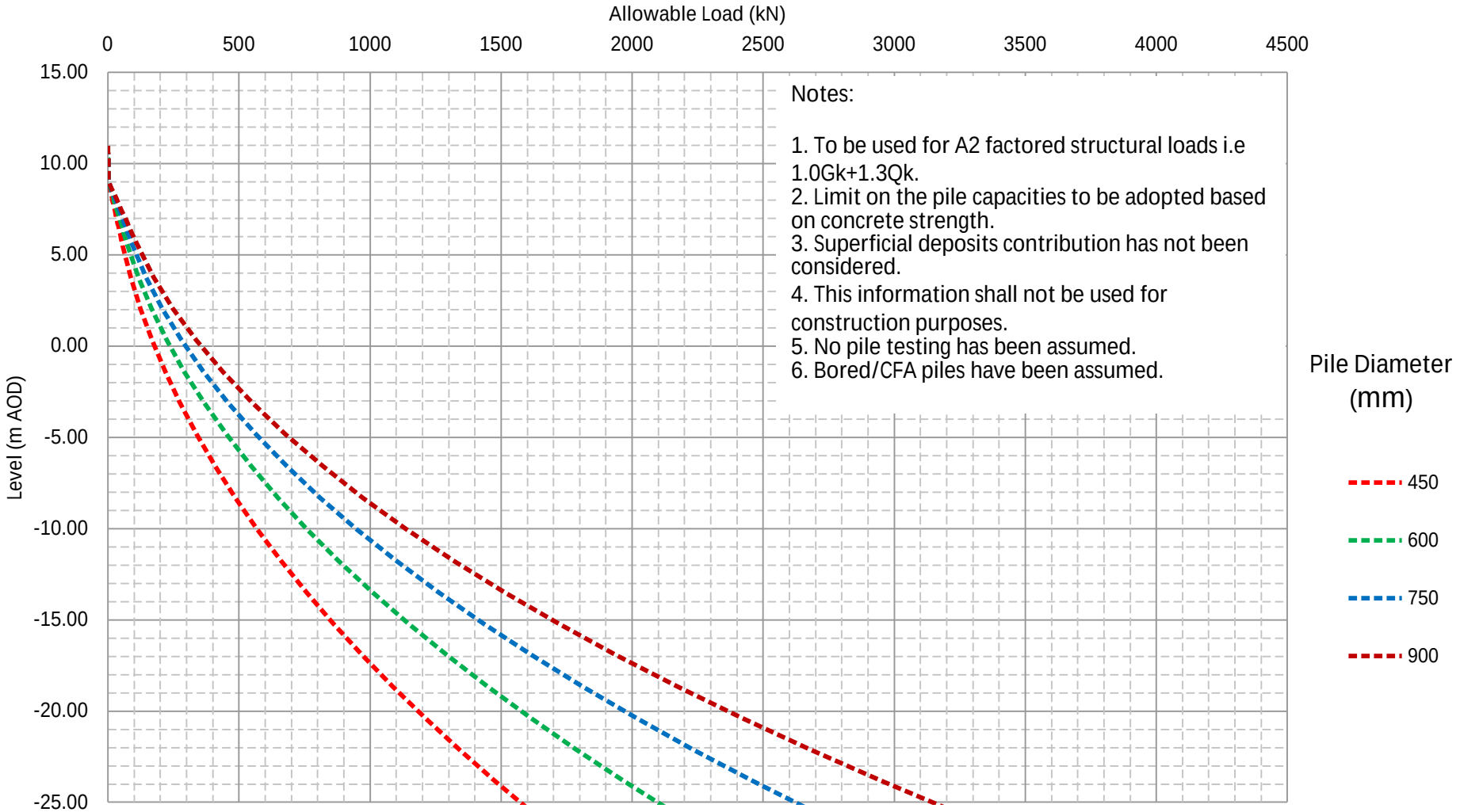
Ground Model 2 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Tension



Ground Model 3 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Compression



Ground Model 3 - Project Otter
Preliminary Pile Design Resistance
Eurocode 7 Design Approach 1 Combination 2 - Tension



D. Geotechnical Risk Register

Likelihood		Severity				
		1	2	3	4	5
		Minor	Moderate	Serious	Major	Catastrophic
1	Extremely unlikely	1	2	3	4	5
2	Unlikely	2	4	6	8	10
3	Likely	3	6	9	12	15
4	Extremely likely	4	8	12	16	20
5	Almost certain	5	10	15	20	25

Potential severity of harm occurring		
1	Minor	Minor damage or loss – (No human injury)
2	Moderate	Moderate damage or loss – (Slight injury or illness)
3	Serious	Substantial damage or loss – (Serious injury or illness)
4	Major	Major damage or loss – (Fatal injury or illness)
5	Catastrophic	Catastrophic damage or loss – (multiple fatalities)

Risk Classification	
Low (1 – 8)	Ensure assumed control measures are maintained and reviewed as necessary
Medium (9 – 19)	Additional control measures needed to reduce risk rating to a level that is equivalent to a test of 'reasonably required' for.
High (20 – 25)	Activity not permitted. Hazard to be avoided or risk to be reduced to tolerate level.

Risk ID	Hazard	Consequence	Likelihood	Severity	Risk	Mitigation	Likelihood	Severity	Residual Risk
1	Ground movements of structures greater than anticipated, hence requiring additional mitigation	Greater movements than anticipated which can cause major issues during construction along the whole line asset. Differential movements and cracks in the concrete structures could occur due to compressible ground, which can require mitigation.	3	5	15	Detailed movement analysis to inform suitable foundation treatment, with aligned construction sequence to reduce post construction movements	1	5	5
2	Foundation instability due to soft ground is weaker than assumed under the foundation and at transition zones	The presence of week ground can result in stability problems along the structures and at transition zones	3	5	15	Detailed design of ground improvements, such as increase of excavation and soil replacement. Installation of drains or tighter grid spacing etc. if necessary.	1	5	5
3	High groundwater and potential inflow issues Decreased effective vertical stress	High groundwater anticipated in the GIR can result in stability issues. Furthermore, it can cause cracks in the concrete structures, which can require repairs.	2	5	10	Groundwater monitoring has been completed. Adequate drainage system and culverts around the asset, if necessary. Drainage system is designed and requires maintenance.	1	5	5

Appendices

Ground Investigation Report

Document Reference: WIE17469

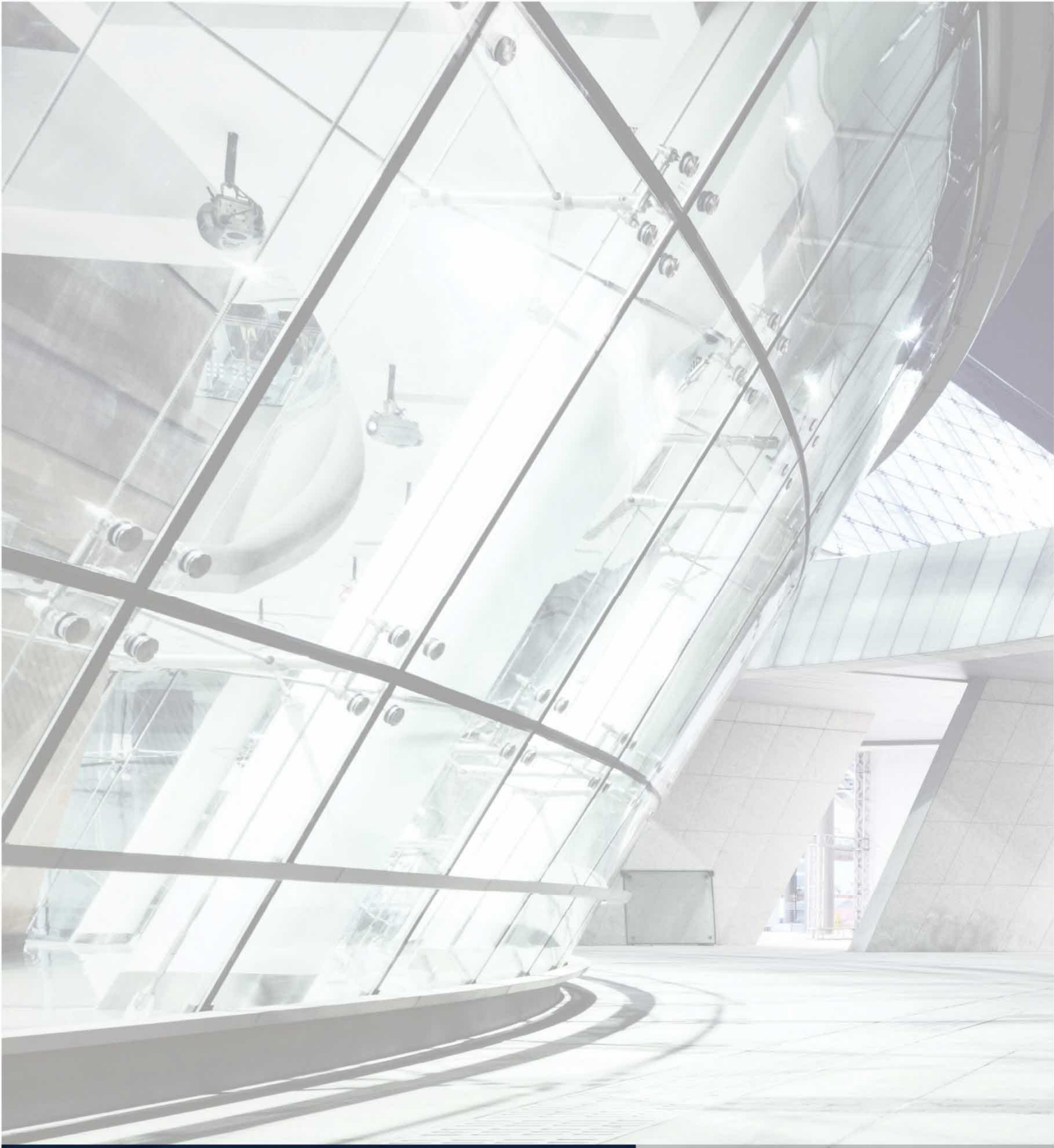
WIE17469-109-R-14-1-4.GIR

4	High sulphate level impacting design of structures and material re-use.	Corrosion potential of concrete structures and extensive swelling if the material is re-used and treated with lime	2	5	10	Buried Concrete Assessment has been carried out to inform DS and ACEC classes for concrete/ Durability report to be produced as part of the final design if required.	1	4	4
5	Extended hold period and increased surcharge requirements	The predicted time to complete settlement is extended due to continued unforeseen settlements. Greater settlements than anticipated can cause major issues during construction along the proposed structures and the adjacent structures.	3	5	15	Further ground movements analysis required to confirm potential for settlement and rate of settlement.	1	5	5
6	Locally hard bands / hard ground is identified within strata with widely variable strength and consolidation characteristics	Difficulties in installing piles, drainage, or service trenches. Potential for differential settlement.	3	5	15	Provision for excavation techniques for hard digging. Potential dig out and replace or construction of transition zone across potential 'hard spots'.	3	5	15
7	Changes in soil volume by shrinking or swelling from changes in moisture content independent of loading leading to ground movements	Shrinkage and swelling of formation soils and causing changes in ground stress and the development of earth pressures, ground movement and cracking in soil deposits.	2	5	10	Control drainage to limit change in water content of soil. Stabilise the soil to alter / control the ground conditions. Excavate and replace	2	3	6

		Longitudinal and lateral shrinkage / swelling in subgrade formation leading to uneven track profile and unacceptable total and differential settlements. Differential ground movements causing damage to foundations. Cracking of formation leading to deformation of drainage system.				susceptible soils.			
8	Presence of disturbed or softened soils including the presence of involutions which weaken the in-situ geology and generate mixed/disturbed soil potentially with shear surfaces / shear bands	Localised soft / disturbed ground requiring replacement or treatment as part of earthworks. Variable settlement / local instability as a result of placing fill, piles or loading above the disturbed zone.	1	4	4	Excavate and replace softened material. Deepen foundations to below disturbed weakened material. Provision of reinforcement to strengthen / stiffen base of earthworks.	1	4	4
9	Poorly backfilled/reinstated longitudinal service tranches and leaking pipework.	Water ingress into excavations causing instability/failure.	4	4	16	Ensure appropriate specification documentation provided to site personnel to emphasise the need to mitigate the risk. Works to be supervised by an appropriate qualified	1	4	4

						geotechnical professional.			
10	Damage to existing services	Disruption of existing buried services like gas, electric cables and sewers, water mains	4	4	16	All relevant information by asset owners and surveys to be provided to the contractor prior the commence of site works. Monitoring of the ground surface will allow any pre-existing issues to be recognised, allow control of the works, demonstrate whether movements are consistent with predictions and enable improved predictions to be made in future works. Ground Movement Analysis TBC to assess the potential impact on existing services.	1	4	4
11	Pile capacities not as anticipated due to weak / fractured zones in the founding layer.	Instability/failure of structures due to bearing capacity failure	3	5	15	Final design of the piles should be carried out in accordance with the individual existing GI information related to each location. Pile testing is recommended to assess the pile capacities on site and validate the final design.	2	4	8

E. Factual Report



GROUNDTECH
CONSULTING

Job title:	Project Otter
Report type:	Factual Geo-Environmental Report
Prepared for:	RMPI Railpen
Date:	January 2023

Document Control Form	
PROJECT	*PROJECT OTTER*
REPORT NAME	*FACTUAL GEO-ENVIRONMENTAL REPORT*
REPORT REFERENCE	*GRO-22165-4080*
STATUS	*DRAFT*
ISSUE DATE	*24 JANUARY 2023*
REVISION	
CLIENT	*RMPI RAILPEN*
CLIENT CONTACT	-
For and Behalf of Groundtech Consulting	
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AUTHOR	Michael Berry MGeo (Hons) FGS
SIGNATURE	
CHECKED	Callum Holden BSc (Hons) FGS
SIGNATURE	
REVIEWED	James Doyle BSc (Hons) CGeol FGS

TABLE OF CONTENTS

Plans		
Plan Reference	Revision	Title
GRO-22212-P01	-	Project Location Plan
GRO-22212-P02	-	Exploratory Hole Location Plan

1.0 INTRODUCTION

1.1 Project Objectives

Groundtech Consulting Limited have been instructed by Gardiner & Theobald LLP on behalf of RMPI Railpen to undertake a Ground Investigation for a site at Cambridge and Beehive Retail Parks, Cambridge

A main investigation was undertaken in accordance with BS 5930:2015, BS 10175:2013, BS 8576 and BS 22475.

1.2 Proposed Development

The proposed Development comprises 14 building plots, 1 to 9 storeys in height for commercial use. A five-storey office block and modification of existing units on the Cambridge Retail Park is proposed to accommodate the relocation of tenants on the beehive retail centre. Soft communal landscaping is proposed with Sustainable Urban Drainage Systems (SUDs).

1.3 Limitations

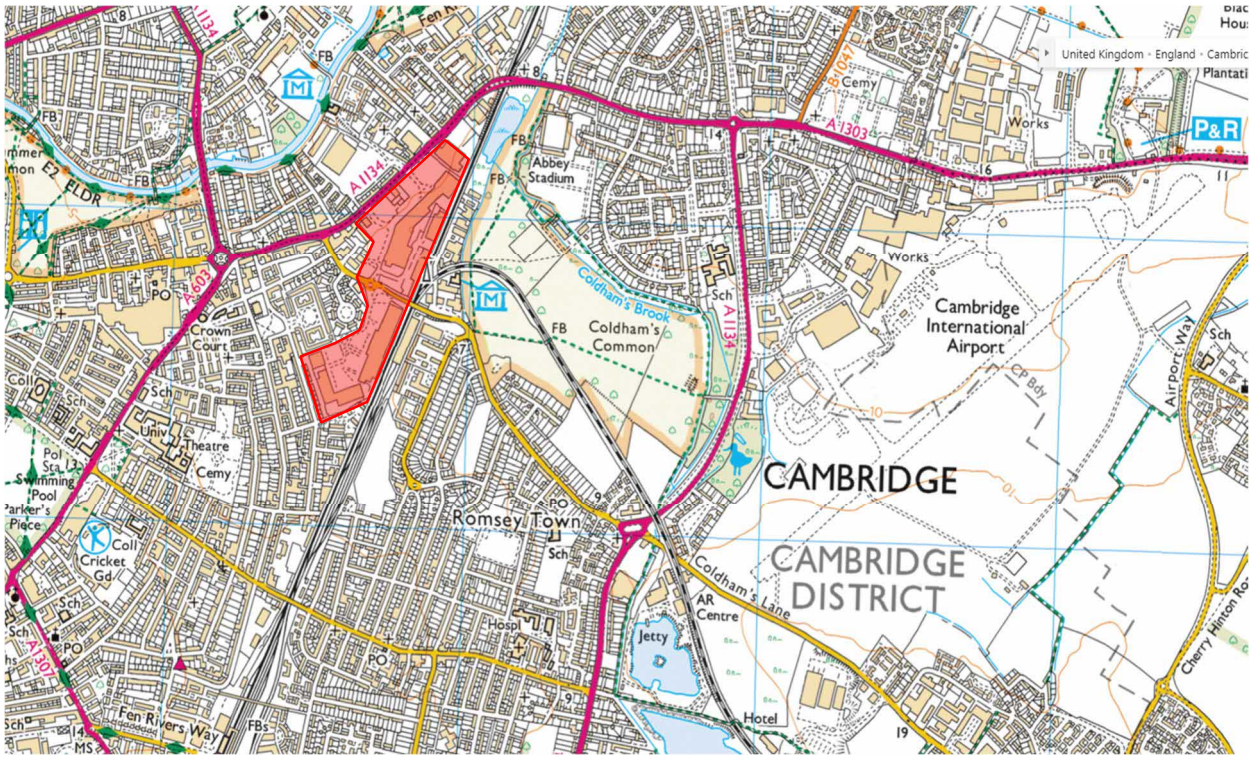
Other conditions may exist on the site that have not been taken into account in this assessment as they are outside the scope of works. Groundtech Consulting are not responsible for these circumstances that are not outlined in the report.

The assessment has been prepared for the exclusive use of the client. No third parties may rely on or reproduce the contents of the report without the written permission of Groundtech Consulting Limited. If any unauthorised third party comes into possession of the report, they rely on it at their own risk and Groundtech Consulting Limited will not be obliged to provide a duty of care.

2.0 SITE SETTING

2.1 Location

The site is located circa 1.0 miles east of Cambridge International Airport, as shown on the Project Location Plan GRO-22165-P01 and is approximately centred on National Grid Reference 546586 258736.



Project Location

Access to the site is gained off Coldhams Lane which bisects the two areas of the site.

2.2 Site Description

The site is irregular in shape and is generally flat lying topographically. The site is currently developed as two retail parks with associated public parking, storage, loading yards and some soft landscaping. The site is divided into northern and southern sections bisected by Coldhams lane which runs roughly east-west between the two areas.

Northern Area - Cambridge Retail Park

The northern site area is approximately 13.0 hectares in area and occupied by Cambridge Retail Park. The site is occupied by various commercial, retail and food outlets housed predominantly within a large elongate building that runs roughly along the centre of the site from south to north. The commercial premises are occupied by business including Halfords, Boots, Currys, Lidl and Homebase.

A cluster of three smaller commercial buildings is located in the southwestern area of the site including a Nando's and ScS.

A disused service yard is present in the west of the site housing a 20ft container.

The remainder of the site consists predominantly of access roads, paved areas, hard surfaced tarmac car parks and concreted storage and service yards to the east of the buildings. There are numerous soft landscaped borders around the car park perimeters, vegetated with bushes, shrubs, saplings and semi-mature trees.

Site Boundaries and Surrounding Features

The site boundary is the edge of the retail park which is marked by Coldhams Lane to the south and predominantly by Henley Road to the east. The western and norther boundaries are marked by adjacent commercial premises.

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

- North - Retail and industrial areas including car dealership and metal recycling plant.
- East - Commercial units and Railway lines.
- South - Coldhams Lane and Beehive Retail Park.
- West - Retail units and the A1134.

Southern Area - Beehive Retail Park

The southern section of the site is approximately 9.0 hectares and is occupied by Beehive Retail Park.
The east, south and south west of the site are occupied by several large retail units which house numerous retail outlets and food outlets including Asda, TK Maxx, Subway, B&M, Pets at Home, Hobbycraft and a gym.

The remaining central northern area of the site is predominantly occupied by tarmac surfaced car parks with numerous access roads. There are numerous soft landscaped borders around the car park vegetated with bushes, shrubs, saplings and semi-mature trees. Semi-mature trees are generally present frequently throughout the car park area between parking spaces.

Service yards, that are both concrete and tarmac surfaced are present along the eastern and southern site boundary to the rear of the commercial units.

Site Boundaries and Surrounding Features

The site boundary is the edge of the retail park which is marked by Coldhams lane to the north. The railway line marks the eastern boundary. The western and southern boundaries of Beehive retail park is marked by a residential area.

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

- North - Coldhams Lane and Cambridge Retail Park.
- East - Railway and residential housing.
- South - Residential housing.
- West - Residential housing.

Site photographs are presented in Appendix 2.

3.0 SCOPE OF INVESTIGATION AND RATIONALE

3.1 Project Objectives

The aim of the fieldwork was to:

Determine the stratification beneath the site.
Maintain a watching brief for visual and olfactory evidence of contamination.
Obtain samples using methodology in current guidance for contamination analysis.
Obtain samples using methodology in current guidance for geotechnical analysis.
Determine the presence of obstructions and buried structures.
Record details of buried services encountered.
Install standpipes for gas and groundwater monitoring.

3.2 Scope of Works

The following scope of works was completed between 31st October and 2nd December 2022:

- All exploratory hole locations were cleared by a specialist service clearance team prior to breaking ground including GPR and CAT scanning.
- Coring of the concrete hardsurfacing was undertaken at 3 No. locations (WBH103, WBH111 & WBH116).
- 6 No. Cable Percussive Boreholes (WBH111-WBH116) were drilled to a depth of 40.0m bgl using a Dando Cable Percussive Rig.
- 2 No. Cable Percussive Boreholes (WBH101 & WBH102) were drilled to a depth of 30.0m bgl using a Dando Cable Percussive Rig.
- 8 No. Cable Percussive Boreholes (WBH103 – WBH110) were drilled to a depth of 25.0m bgl using a Dando Cable Percussive Rig.
- Rotary coring was carried out from 30.0m to 32.0m bgl at WBH111 using a Commacchio 305.
- WBH103A and WBH103B were advanced to depths between 0.25m and 0.27m bgl where they were terminated on a concrete obstruction.
- Photo Ionisation Detector (PID) screening of all environmental samples.
- Radiation Screening of all samples and arisings from within the historical landfill.
- Surveying of all exploratory hole locations to National Grid and meters Above Ordnance Datum (mAOD).
- Reinstatement of all locations.
- Low flow groundwater sampling.

The exploratory hole locations are presented on Groundtech Plan GRO-22165-P02, and the exploratory hole logs are presented in Appendix 3.

The exploratory hole locations were positioned by Waterman I&E to establish the stratification beneath the site and target areas of concern as set out in the specification. The exploratory holes were logged by a suitably experienced geo-environmental engineer in general accordance with the following current guidance:

- BS 5930 'Code of Practice for Site Investigations' 2015.

- BS EN 14688-1:2002 'Geotechnical Investigation and Testing – Identification and classification of soil'.
- BS EN ISO 14689:2002 'Geotechnical investigation and testing – Identification and classification of rock'.
- CIRIA C574:2002 'Engineering in Chalk'.
- Mortimore, R.N. 2014 'Logging the Chalk'.

3.3 Soil Sampling

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

The samples obtained are summarised in the table below:

Soil Sample	Number
Disturbed Sample	447
Bulk Sample	373
Undisturbed U100 Sample	143
Environmental Sample	251

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

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

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

3.4 Geo-Environmental Analysis

All testing was scheduled by Waterman I&E. A summary of the testing scheduled is below and the results of the geo-environmental testing is present in Appendix 4.

Contaminants of Concern	Matrix	Number
Metals Suite	Soil	35
Speciated PAHs 17	Soil	33
Speciated TPH CWG (C5 – C44), BTEX, MTBE	Soil	32
VOCs	Soil	36
SVOCs	Soil	29
Complex Cyanide, Total Cyanide, Free Cyanide	Soil	15
PCBs	Soil	5
Ammoniacal Nitrogen, Ammonia, Ammonium (NH4+)	Soil	33
Speciated Phenols	Soil	1
SOM, pH, TOC, FOC, sulphate, sulphide, moisture content	Soil	30
Asbestos Screen	Soil	26
Waste Acceptance Criteria (WAC)	Soil	5
Metals Suite	Groundwater	14

Speciated PAHs 17	Groundwater	14
Speciated TPH CWG (C5 – C44), BTEX, MTBE	Groundwater	14
VOCs	Groundwater	14
SVOCs	Groundwater	14
Ammoniacal Nitrogen	Groundwater	14
Cyanides - Total, Free, Thiocyanate	Groundwater	14
Sulphate	Groundwater	14
Chloride	Groundwater	14
pH and Total Hardness	Groundwater	14

3.5 Geotechnical Analysis

All testing was scheduled by Waterman I&E. A summary of the testing scheduled is below and the results of the geotechnical testing is present in Appendix 5.

British Standard	Test Method	Number
Part 2	Water Content	14
Part 2	Plasticity Index Analysis	40
Part 7	Undrained Shear Strength in Triaxial Compression	43
BRE SD1	BRE Suite D Brownfield (Pyrite present)	30
Part 4	California Bearing Ratio Test	5
Part 7	Consolidated Drained Shearbox Test	16
Part 2	Particle Size Distribution	44
Part 2	Particle Size Distribution Test Pipette Analysis	24
Part 9	Unconfined Compressive Strength	4
Part 9	Point Load	6
Part 5	One Dimensional Consolidation Test	5
Part 7	Quick Undrained Shear Box Test	2
BRE SD1	Organic Content	2
Part 6	Permeability in a Triaxial Cell	2
Part 4	2.5kg Compaction Test	2

3.6 Gas and Groundwater Monitoring

Gas and groundwater monitoring installations were constructed in the boreholes under the instruction of Waterman I&E. The standpipes consisted of high-density polyethylene (HDPE) pipe - a bentonite seal was placed around the plain pipe and a clean gravel pack was placed around the slotted pipe. A summary of the installation construction is presented in the table below:

Location	Depth (m bgl)	Response Zone (m bgl)	Targeted Strata	Reason
WBH101	6.00	2.00 – 6.00	Chalk	Ground Gas & Groundwater
WBH102	4.00	1.00 – 4.00	Made Ground & Chalk	Ground Gas & Groundwater
WBH103	2.00	1.00 – 2.00	Made Ground	Ground Gas
WBH104	2.00	1.00 – 2.00	Made Ground	Ground Gas within historic landfill.

	16.00	4.00 – 16.00	Made Ground	Ground Gas & Groundwater within historic landfill.
WBH105	3.00	1.00 – 3.00	Made Ground	Ground Gas & Groundwater within historic landfill.
	10.00	4.00 – 10.0	Made Ground	Ground Gas & Groundwater within historic landfill.
WBH106	4.00	1.00 – 4.00	Made Ground & Chalk	Ground Gas
WBH107	4.00	2.00 – 4.00	Chalk	Ground Gas
WBH108	2.00	1.00 – 2.00	Made Ground	Ground Gas & Groundwater within historic landfill.
	9.50	4.00 – 9.50	Made Ground	Ground Gas & Groundwater within historic landfill.
WBH109	2.00	1.00 – 2.00	Made Ground	Ground Gas
	9.00	3.00 – 9.00	Made Ground, Chalk & Organic Clay	Ground Gas & Groundwater
WBH110	3.00	1.00 – 3.00	Made Ground, Clay & Chalk	Ground Gas
WBH111	6.00	1.00 – 6.00	Chalk	Ground Gas & Groundwater
WBH112	6.00	1.00 – 6.00	Chalk	Ground Gas & Groundwater
WBH113	7.00	1.00 – 7.00	Gravelly Sand, Clay & Chalk	Ground Gas & Groundwater
WBH114	1.50	0.50 – 1.50	Made Ground	Ground Gas
	5.50	2.50 – 5.50	Chalk	Ground Gas & Groundwater
WBH115	4.00	1.00 – 4.00	Made Ground & Chalk	Ground Gas & Groundwater
WBH116	5.00	1.00 – 5.00	Made Ground & Chalk	Ground Gas & Groundwater

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

- Oxygen (O_2), carbon dioxide (CO_2) and methane (CH_4) as the percentage volume in air (%v/v).
- Hydrogen sulphide (H_2S) and carbon monoxide (CO) as the percentage volume in air (%v/v).
- Lower Explosive Limit (%LEL) of methane.
- Atmospheric and borehole pressure, including pressure trend.
- Flow measurements (l/hr).
- Weather and ground surface conditions.

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

Gas monitoring was carried out continuously over a 5-minute period during the monitoring visits. Concentrations were recorded at the following intervals: 10s, 20s, 30s, 45s, 60s, 120s, 180s, 240s and 300s.

Interim permanent gas monitoring results are presented in Appendix 6.

Groundwater Sampling

Well development was carried out to ensure no cross contamination from the drilling activities remained in the water column in the well. The installations were purged to a minimum three times the volume of the water column in the borehole prior to sampling.

Purging was undertaken at a slower rate than the well development, and the sampling at a slower rate again.

The method of sampling selected was using low flow pumping techniques as set out in the specification.

Where possible, a water meter was used to test the pH, temperature and conductivity before sampling until equilibrium conditions were met, as per BS 10175 guidelines.

Samples were sent to the UKAS Accredited laboratory the same day sampling was carried out in general accordance with BS593010 and BS5667-1111.

All groundwater contamination testing was scheduled by Waterman I&E.

3.7 Vapour Survey - Photo Ionisation Detector

Standard sampling protocol and preservation of samples was undertaken as described in the EA guidance on site investigation. The onsite monitoring was carried out in line CIRIA C6658 to aid targeting samples for VOC laboratory analysis.

Soil was collected for onsite testing. A plastic bag was half filled with soil allowing a suitably sized headspace. The bag was sealed and stored for at least 20 minutes before being tested for Total Volatile Organic Compounds (TVOCs) using a Photo Ionisation Detector (PID). Results of the PID readings are presented in Appendix 7.

3.8 Rotary Coring Follow-on

Rotary coring follow-on was programmed to be undertaken at locations WBH111 to WBH116 at the base of the cable percussive boreholes where SPT refusals were anticipated in the Gault Clay. It was anticipated that rotary coring techniques would be required to complete the deeper boreholes.

WBH111 was the first borehole undertaken and rotary coring was attempted from 30.0m bgl after two SPT refusals had been recorded. Two 1m rotary core runs were undertaken between the depths of 30.0m bgl and 32.0m bgl within the very stiff Gault Clay deposits. However, no recovery was observed from the two core runs. Discussions between Groundtech Consulting and Waterman I&E concluded that the remainder of the boreholes would be completed using Cable Percussive methods to the base of the boreholes.

3.9 Scintillometer Results

A scintillometer was used during the works to detect possible radioactive material within the Made Ground soils, particularly within the landfill material. Levels recorded during the work were equivalent to background level throughout the works.

4.0 GROUND MODEL

4.1 Made Ground

Made Ground was encountered in all of the boreholes to a maximum depth of 15.9m bgl in WBH104 in the central southern area of the Cambridge Retail Park site. In the Cambridge Retail Park site, deep Made Ground was encountered to depths between 4.6m and 15.9m bgl, in the central and eastern areas of the site, associated with a former landfill. In the remaining boreholes, the Made Ground was encountered to depths between 1.4m and 2.2m bgl.

Made Ground was encountered to depths between 0.35m and 2.5m bgl in the Beehive Retail Park site.

Surfacing

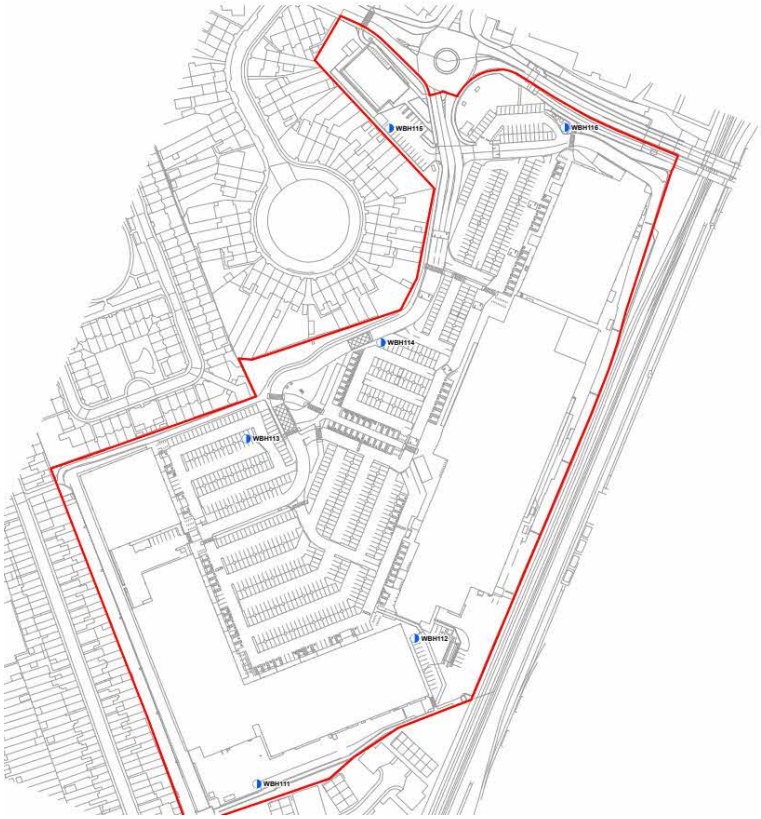
Tarmac surfacing was present at all locations with the exception of WBH111 and WBH116 from ground level to a maximum depth of 0.27m bgl. WBH111 and WBH116 were surfaced with concrete which was encountered from ground level to a maximum depth of 0.30m bgl. Reinforced concrete was also encountered underlying the tarmac surfacing of WBH103, WBH103A and WBH103B between the depths of 0.26m and 0.55m bgl where fully penetrated.

The site can be divided into Beehive Retail Park in the south which contains boreholes WBH111 to WBH116 and Cambridge Retail Park in the north containing boreholes WBH101 to WBH110. The ground conditions for the two sperate areas of the site are described below.

Beehive Retail Park (WBH111-WBH116)

Made Ground was encountered to depths between 0.35m and 2.5m bgl and comprised four main strata described below:

- Brown gravelly occasionally clayey fine to coarse sand with minor constituents of brick, sandstone, concrete, tarmac, quartzite and chert was encountered in WBH111 and WBH113 to WBH116 from 0.1m bgl to a maximum depth of 1.1m bgl.
- Brown sandy gravel of mixed lithologies including limestone was encountered in WBH112 between 0.1m and 0.7m bgl and WBH113 between 0.09m and 0.2m bgl.
- Firm brown sandy gravelly clay was encountered in WBH115 and WBH116 between 0.7m and 1.5m bgl.
- Reworked structureless chalk composed of light grey firm gravelly cobbly clay was encountered in WBH114 to WBH116 from depths between 0.9m and 1.7m bgl to a maximum depth of 2.5m bgl.



Exploratory Hole Locations for Beehive Retail Park

Cambridge Retail Park (WBH101-WBH110)

Made Ground was encountered to a maximum of 15.9m bgl in the area of the former landfill. Where landfill was not encountered, the maximum recorded depth of the Made Ground was between 1.4m and 2.2m bgl.

The following four main Made Ground populations were encountered up to a depth of 2.2m bgl:

- Brown gravelly occasionally clayey sand is present in WBH102, WBH104, WBH105, WBH107, WBH109 and WBH110 from a minimum depth of 0.1m bgl to a maximum observed depth of 2.0m bgl.
- Brown sandy clayey gravel was observed in WBH102, WBH103, WBH104, WBH108 and WBH109 from a minimum depth of 0.1m to a maximum depth of 2.0m bgl.
- Soft to firm sandy gravelly clay was present in WBH101, WBH105, WBH106 and WBH109 from depths of between 0.12m and 1.0m bgl to a maximum depth of 2.0m bgl.
- Reworked structureless chalk composed of firm light grey gravelly cobbly clay was encountered in WBH101 to WBH103 and WBH109 from a minimum depth of 0.75m bgl to a maximum depth of 2.2m bgl.

The deeper landfill populations encountered in WBH104, WBH105, and WBH108 to a maximum depth of 15.9m bgl are described below:

- Soft to firm gravelly ashy clay with a high cobble content was encountered in WBH104, WBH105 and WBH108 from depths between 1.5m and 6.0m bgl to a maximum depth of 13.0m bgl. Minor constituents observed included wood, brick, glass, concrete, tiles, plastic, metal including copper,

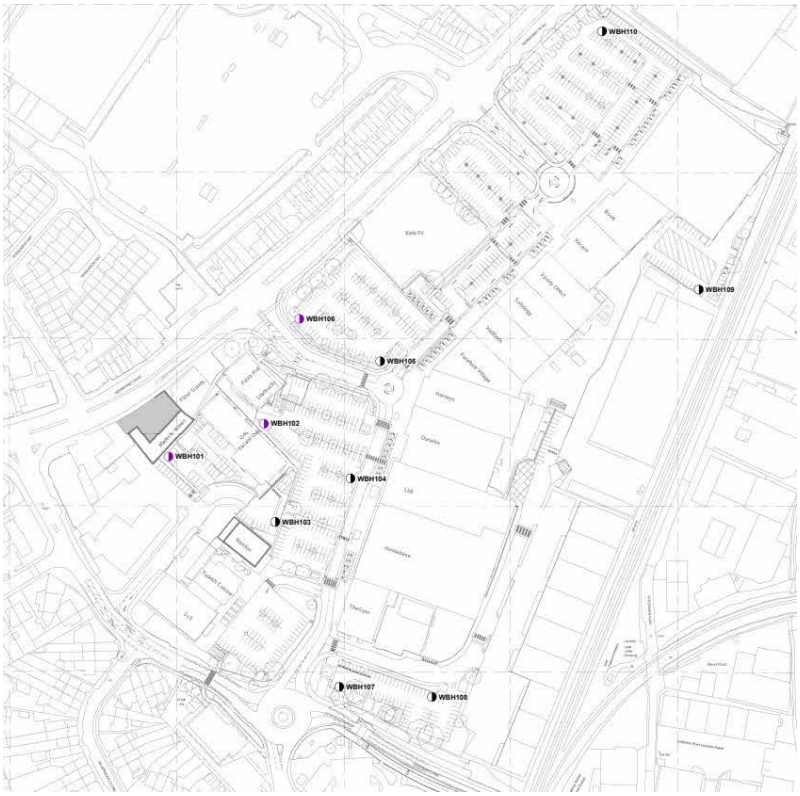
fabric and leather, bones, pottery, rubber and glass bottles. A moderate organic odour was also noted in this stratum as well as a hydrocarbon odour in WBH104 and WBH108.

- Black clayey gravel was noted within WBH104 between depths of 4.9m and 6.0m bgl and again between 13.0m and 15.9m bgl. This stratum was also encountered in WBH108 from depths between 2.0m and 6.0m bgl and minor constituents included wire, copper, wood, metal, cloth, plastic, brick, tiles, glass, string, fabric, rubber and carpet. A solvent and hydrocarbon odour was noted within this stratum.

Reworked structureless chalk composed of firm to stiff sandy gravelly clay was encountered in WBH109 from 2.0m bgl to 4.6m bgl on the northern edge of the landfill.

Reworked structureless chalk composed of silty gravelly clay was encountered in WBH105 between depths of 10.0m and 14.0m bgl underlying the landfill material.

Poor recovery was recorded at location WBH105 between 5.0m bgl and 10.0m bgl within the landfill material due to water ingress.



Exploratory Hole Locations for Cambridge retail Park.

4.2 Natural Ground

Natural strata were only observed in WBH113 and consisted of light brown gravelly medium to coarse sand from 0.85m to 2.6m bgl. This confirms the records from the geological maps where river terrace deposits are indicated in this area. This was underlain by soft to firm gravely sandy clay from 2.6m to 5.5m bgl.

4.3 Bedrock

Bedrock was encountered in all the boreholes, except from WBH103A and WBH103B from depths between 0.35m and 15.9m bgl. Chalk of the West Melbury Marly Chalk Formation was encountered in all boreholes, except for WBH104, WBH105 and WBH108, from depths between 0.35m bgl and 4.6m bgl to a maximum depth of 7.0m bgl. This was in turn underlain by Clay of the Gault Formation to the base of the boreholes.

At locations WBH104, WBH105 and WBH108, in the Cambridge Retail Park area, the Made Ground soils were directly underlain by the Gault Clay.

The chalk was generally recorded as structureless chalk composed of soft to firm cream mottled yellow to brown silty gravelly, occasionally cobbly clay with weak low-density clasts encountered in WBH101 to WBH103, WBH106 to WBH107 and WBH109 to WBH116 (Grade Dm).

Structureless Chalk composed of light grey clayey gravelly cobbles with weak low-density clasts (Grade Dc) was encountered in WBH114 between 2.5m and 3.8m bgl.

The Gault Formation generally comprised of stiff to very stiff high strength to very high strength grey silty clay encountered in all boreholes from depths between 3.2m and 15.9m bgl to a maximum observed depth of 40.0m bgl.

Locally soft clay was encountered at locations WBH109 between 6.3m and 9.4m bgl and WBH110 between 2.5m and 3.2m bgl.

4.4 Groundwater

Groundwater was encountered in the majority of the boreholes during the investigation at depths between 1.5m and 4.5m bgl. Groundwater strikes are summarised in the table below:

Location	Depth (m bgl)	Strata	Type
WBH101	3.5	Chalk	Strike
WBH102	2.5	Chalk	Seepage
WBH103	2.5	Chalk	Strike
WBH104	3.8	Clay Made Ground (Landfill)	Strike
WBH105	3.5	Clay Made Ground (Landfill)	Strike
WBH106	NGW	-	-
WBH107	NGW	-	-
WBH108	1.5	Gravel Made Ground (Landfill)	Strike
WBH109	NGW	-	-
WBH110	4.0	Gault Clay	Seepage
WBH111	4.5	Chalk	Strike
WBH112	3.5	Chalk	Strike
WBH113	3.5	Gault Clay	Strike
WBH114	3.5	Chalk	Strike
WBH115	2.6	Chalk	Strike
WBH116	4.5	Chalk	Strike

4.5 Watching Brief

A watching brief was maintained during the Ground Investigation for visual and olfactory evidence of contamination. The contamination identified is detailed in the table below.

Location	Depth (m bgl)	Visual Evidence	Olfactory Evidence
WBH102	0.4 - 1.2	Slag in Made Ground	-
WBH104	0.1 - 15.9	Landfill Material encountered	-
WBH104	1.5 - 4.9	-	Moderate organic odour
WBH104	4.9 - 6.0	-	Strong organic odour
WBH104	6.0 - 8.0	-	Moderate organic odour
WBH104	8.0 - 11.0	-	Strong hydrocarbon odour
WBH104	11.0 - 13.0	-	Moderate hydrocarbon odour
WBH104	13.0 - 15.9	-	Moderate organic odour
WBH105	0.1 - 14.0	Landfill Material encountered	-
WBH105	0.75 - 10.0	-	Faint to moderate organic odour
WBH105	1.50 - 5.0	Ash present with Made Ground	-
WBH108	0.1 - 9.5	Landfill Material encountered	-
WBH108	1.0 - 6.0	-	Faint solvent odour
WBH108	8.0 - 8.5	-	Faint hydrocarbon odour
WBH110	0.75 - 1.9	Slag present in Made Ground	-
WBH111	0.5 - 2.5	-	Moderate to strong solvent odour in Chalk

4.6 Excavation Stability

Boreholes within the landfill were cased of to prevent collapse. It is anticipated that the landfill material would have been unstable and prone collapse due to the loose nature of the material and water ingress noted.

4.7 Borehole Progress/Obstructions

Several minor obstructions were encountered during the investigation as detailed in the table below:

Location	Depth (m bgl)	Obstruction
WBH103	0.26 – 0.55	Grey reinforced concrete
WBH103A	0.25	Grey concrete
WBH103B	0.27	Grey concrete
WBH106	0.2 – 1.0	Concrete – Poor condition
WBH109	0.9	Geogrid encountered
WBH110	0.5	Geogrid encountered
WBH115	0.4 – 0.7	Concrete

Concrete was encountered at locations WBH103A and WBH103B and these locations were subsequently relocated to WBH103. Concrete was still present at this location and concrete coring was undertaken to progress through the obstruction.

An SPT refusal was recorded in the dense Made Ground deposits in the landfill material within WBH105 at 4.5m bgl.

SPT refusals were recorded in the stiff to very stiff high to very high strength Gault Formation from depths between 24.0m and 37.5m bgl at locations WBH107, WBH111 – WBH1114 and WBH116.

No underground utilities were encountered during the works.

5.0 RELEVANT INDUSTRY REFERENCES

British Standards Institution 'Investigation of Potentially Contaminated sites - code of practice' BS 10175:2017.

British Standards Institution 'Code of Practice for Site Investigations' BS 5930:2015

British Standards Institution 'Geotechnical investigation and testing – Identification and classification of soil' BS EN ISO 14688:2002.

BS EN ISO 14689:2002 'Geotechnical investigation and testing – Identification and classification of rock'.

CIRIA C574:2002 'Engineering in Chalk'.

Mortimore, R.N. 2014 'Logging the Chalk'.

APPENDIX 1 - Plans