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Ground Investigation Report

Proposed Residential Development

Cowm Top, Rochdale

December 2024



Project Details

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Drawing Register

Title	Produced by	Date	Reference
Cut and Fill Appraisal	Barratts Homes Manchester	September 2024	H8544-BAH-XX-XX-DR-CE-202700-P01
Location Plan	Barratts Homes Manchester	March 2022	496-P-LP-01 Rev1
Intrusive Investigations and Zoning	Smith Grant LLP	21 st July 2017	R2392-001
Exploratory Hole Location Plan	Soiltechnics Ltd	December 2024	STV5936-D01A-A
Shallow Soil Sampling Location Plan	Soiltechnics Ltd	December 2024	STV5936-D01B-A
Exploratory Hole Location Plan with Cut and Fill and Development Layout	Soiltechnics Ltd	December 2024	STV5936-D02-A
Plan Showing Groundwater Flow Direction	Soiltechnics Ltd	December 2024	STV5936-D03-A

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Non-technical Summary

Topic	Commentary
Site description	The site comprises a disused parcel of land known as 'Cowm Top', in Castleton, on the south-western outskirts of Rochdale. The site comprises agricultural land, formerly used as land for grazing, covered in grassland, heath and scrub. The site generally slopes from the highest point within the northeast corner (~183m AOD) towards the southwest adjacent to Trows Lane (~148m AOD). Within the site, surface levels have extensive undulations, with 2 No. prominent valleys, varying by up to 10-15m in height in areas.
Development proposals	Construction of 445 No. low rise residential dwellings. As part of the scheme, earthworks reprofiling will be undertaken to facilitate development due to the hummocky terrain.
Previous Investigations	Soiltechnics have previously completed a preliminary slope stability assessment, coal mining risk assessment and gas main impact assessment (refer to Section 1 for further details). In addition, Phase 1 and Phase 2 ground investigations have previously been undertaken by Smith Grant LLP. Following completion of such works, further works were required to facilitate development of the site and address planning.
Ground conditions	Ground conditions of the site consist of Topsoil across the entirety of the site. Made Ground was identified in 3 No. main areas – the southeast corner of the site, at the base of the existing valley in the west of the site (north of Trows Farm) and in the northeast of the site. Made Ground in the southeast corner of the site was most widespread and varied between 0.45-2.80m in thickness and comprised suspected reworked material from the construction of the adjacent A627(M). Made Ground in the west and northeast of the site was more localised and between 0.3-1.4m thick. Topsoil/Made Ground was underlain by Hummocky Glacial Deposits encountered as interdigitated layers of clay, silt and sand with minor components of fine to medium gravel. The base of the Hummocky Glacial Deposits was not encountered in any borehole. Alluvium comprising soft silt was encountered in the valley floor in the west of the site 0.9->2.3m thick, and in the eastern valley area during previous investigations by Smith Grant LLP. Groundwater was encountered within the Hummocky Glacial Deposits across the site. Level logger data from the last 4 months suggests levels are consistent in each area of the site, with a quick response to rainfall events noted. Based on water levels measured to date, groundwater flow is generally funnelled to the southeast and southwest along the existing valleys. Shallow groundwater was recorded in wells in the northwest corner of the site. It is anticipated that these groundwater levels relate to perched groundwater within more granular superficial deposits and are not expected to be representative of the groundwater table.
Foundation, floor slab and pavement formation	Extensive cut and fill is expected across the site with up to 9m of cut and 10m of fill currently proposed. Where cutting or <1m of fill is expected, shallow traditional spread foundations should provide suitable support, subject to penetration the natural Hummocky Glacial Deposits soils by 0.3m. Deposits of Alluvium and Made Ground will not provide support to spread type foundations. Where >2m of fill is expected to be present, piled foundations are expected to be required. Alternatively, engineering and validation of the proposed fill may allow for the use of raft foundations, as well as reducing the risk associated with differential settlement. A table outlining likely foundation requirements with respect to cut/fill levels across the site is presented in Section 0. Where spread foundations are adopted, ground bearing floor slabs can be adopted where they are remote from trees and where Made Ground/Topsoil/Alluvium deposits are fully removed within the footprint of the building. In areas close to existing major vegetation at the site or if piled foundations are adopted in areas of significant fill then it is recommended that suspended ground floors are adopted. If raft type foundations are adopted, such a foundation solution will provide adequate ground floor support. A concrete classification of DS-1 AC-1s is recommended beneath the site. Low remoulded CBR values were recorded in both fine and coarse-grained Hummocky Glacial deposits. It is recommended that in situ testing of the soils below proposed pavement formation be undertaken following completion of filling operations to confirm California Bearing Ratio (CBR) value prior to road construction. A CBR value of 2.5% could be adopted at this stage as a preliminary design value for areas to be filled, assuming soils would be conditioned to some extent prior to placement. Where natural undisturbed soils are to be left at surface, a CBR of the same value should be adopted at this stage.

Topic	Commentary
Slope Stability	The proposed scheme involves considerable earthworks, where slopes will be cut into the in situ material and also formed with placed material. There will be a degree of material control for the placed slopes. In contrast the cut slopes will be in virgin material, with no control of the material composition. A slope angle of 1V:3H is recommend for slopes cut into existing ground. Slope constructed with the granular Hummocky Glacial Deposits can adopt a slope angle of 1V:2.5H. Drainage should be installed as part of the works such that groundwater does not rise above 1m BGL. In certain locations the proposed finished level will be below the monitored groundwater level. Such a scenario will lead to failure of the slope and must be avoided. Deep drainage could be installed upslope of the problem locations to intercept water before it reaches the surface. This option also has the added benefit of promoting stability during the temporary works and is therefore recommended. Alternatively, proposed levels could be adjusted to ensure cut levels remain above groundwater levels.
Earthworks	We anticipate that coarse-grained and fine-grained Hummocky Glacial Deposits are likely to be classified as Class 1B 'Uniformly Graded Granular' and Class 2A 'Wet Cohesive' in relation to Table 6/1, Specification for Highway Works Series 600. In terms of suitability of site won soils for reuse, The results indicate that the in situ moisture content at time of testing is broadly coincident with the maximum acceptable moisture content, which indicates that the materials are wet of optimum. It is likely that once excavated and mixed, soils will largely be suitable for reuse, but some conditioning (drying out) could be required. Soils will require validation on placement, which is likely to consist of approximately 70% coarse-grained soils and 30% fine-grained soils. Accordingly, testing frequencies are outlined in Section 6.22. It is noted that proposed cut levels are below the groundwater table in 3 No. areas of the site (BH07 south central, BH03 and BH05 on highest plateau and BH11 in the southern part of the site). This is around 1m below cut level, but reaches up to 2m below cut level around BH11. Consideration will need to be given to this and the implications this will have on feasibility of such works. It is likely that proposed ground levels will need to be raised in such areas to ensure groundwater remains below surface level long term, or installation of an adequate permanent drainage solution to collect groundwater before it enters the site. In all other areas of the site where groundwater has been measured to date, levels are well below proposed cut levels and worst case is ~1.5-2.0m below cut. Consideration will need to be given to the consolidation of Alluvium deposits where large volumes of fill are placed above. Excavation and placement elsewhere onsite, or offsite disposal, could be considered.
Drainage potential	The Hummocky Glacial Deposits were observed as variable fine granular and cohesive deposits. Large scale earthworks are proposed, and we would not recommend disposal of stormwater in proximity to slopes and in areas of fill, which could promote collapse settlement and slope instability. It is noted based on previous investigations, permeability was measured between 1.4×10^{-6} m/s to 1.4×10^{-7} m/s, with results suggesting relatively low permeability site wide within natural soils. Qualitative and quantitative assessments indicate that natural Hummocky Glacial Deposits are unlikely to exhibit sufficient permeability to allow the use of SUDS at the site. If such systems are considered, it is recommended that in situ testing within this stratum is undertaken during completion of the earthworks phase of the development to facilitate a quantitative assessment. The in-situ testing should be undertaken in accordance with BRE 365: Soakaway Design (2016).
Chemical assessment	Based on testing to date, existing topsoil resources are considered suitable for reuse in a residential setting without any remedial action from a human health perspective. All significant GAC exceedances in Made Ground arose from areas of SL01 and SL02, where Made Ground was visible from the surface. Asbestos was present in such soil also. Made Ground in this area did not appear to be laterally extensive and was only recorded as 0.3m deep. As such it is recommended that the Made Ground in this area is stripped and either reused beneath buildings/hardstanding/fill (effectively severing the pathway from source to site receptors), or disposed of off-site to landfill under the appropriate duty of care. Construction operatives will need to take special precautions in areas where asbestos is present, including the adoption of RPE (P3 half masks), the use of enhanced personnel decontamination facilities, in combination with localised mechanical dust suppression. Monitoring of the spring locations (where construction permits), and the adjacent ponds to the south, should be undertaken before, during and after construction of the basin, to ensure development it not causing detrimental impact to surface waters.
Radon, gas risk and protection measures	The site is within a lower probability Radon area as such requires no Radon protection measures.

Topic	Commentary
	The absence of methane and significant carbon dioxide concentrations indicates that there is no significant migration of ground gases occurring from nearby infilled land. A CS-1 classification applies to the site. This will be updated where necessary on completion of the monitoring programme.
Waste characterisation and material management	It is anticipated that all soils will be reused onsite, and only natural soils would be disposed/reused offsite. As the reuse of Made Ground soils on site is likely to exceed 1,000 tonnes (U1 Exemption limit), it is recommended that the works are controlled under an MMP in accordance with the CL:AIRE DoW CoP. Should surplus Made Ground be disposed of off-site to landfill it is recommended to undertake additional sampling and testing during the construction works to fully characterise the waste soils intended for disposal.
Recommendation for further works	Discovery strategy for the event of exposing previously unencountered contamination. A Remediation Strategy and subsequent Verification Report on completion. Surface water compliance testing should be completed within springs and adjacent ponds, before, during and after construction to ensure development it not causing detrimental impact to surface waters. A Materials Management Plan to facilitate the reuse of Made Ground materials on site, where necessary, with subsequent verification to demonstrate compliance. If SUDS are considered, it is recommended that in situ testing within this stratum is undertaken during completion of the earthworks phase of the development to facilitate a quantitative assessment. The in-situ testing should be undertaken in accordance with in BRE 365: Soakaway Design (2016). It is recommended that the design CBR values are validated with in situ testing immediately prior to construction.

1 Introduction

1.1 Scheme Outline

- 1.1.1 The overall scheme comprises the development of a parcel of land known as Cowm Top, Rochdale, with construction of 445 No. low rise residential dwellings. As part of the scheme, earthworks reprofiling will be undertaken to facilitate development due to the hummocky terrain. Current development layouts are presented in Appendix A.
- 1.1.2 It is understood that the development is controlled under the Rochdale Borough Council planning regime, under application reference 22/01190/FUL.
- 1.1.3 The report is based on the project proposals and information outlined above; should the scheme change then it will be necessary to review the conclusions and recommendations presented in this report.

1.2 Brief

- 1.2.1 This report has been prepared following instructions received from Barratts Homes Manchester. The overall brief of works is to:

- i) Undertake a ground investigation at the site to establish the prevailing ground conditions and identify potential abnormal development constraints.
- ii) Support the planning application by further assessing the potential risks from contamination at the site, supplementing previous investigations.
- iii) Determine specific soil parameters to provide a geotechnical appraisal and inform a future earthworks and foundation strategy for the scheme.

- 1.2.2 The objectives of this report are outlined below:

- i) Review and summarise previous ground investigation report information.
- ii) Summarise the intrusive investigation works undertaken and associated laboratory testing.
- iii) Undertake a general assessment of potential contamination risks which may affect the development.
- iv) Present a ground model summarising the ground and groundwater conditions at the site including relevant soil parameters to assist foundation and earthworks assessments.
- v) Provide recommendations to inform an Options Appraisal and Remediation Strategy, should they be required.

- 1.2.3 In addition to the above, Soiltechnics have previously completed the following investigations at the site;

- Cowm Top, Rochdale: Preliminary Slope Stability Assessment (Soiltechnics Ltd, March 2023)
Document reference: STV5936-R01-Rev_A. Including baseline surface water sampling and testing.
- Cowm Top, Rochdale: Coal Mining Risk Assessment Report (Soiltechnics Ltd, May 2023)
Document reference: STV5936-CMRA01-Rev_A.
- Cowm Top, Rochdale: Cadent Gas Main Impact Assessment (Soiltechnics Ltd, July 2024)
Document reference: STV5936-R03-Rev_A.

1.3 Definition of Scope

- 1.3.1 The phasing and scope of the ground investigation works is broadly defined by the following documents.

Title	Document Reference	Publisher	Investigation Scope
Code of practice for ground investigations	BS 5930: 2015	British Standards Institution	Phase 3: Detailed (design) investigation
Eurocode 7 — Geotechnical design Part 2: Ground investigation and Testing	BS EN 1997-2: 2007	British Standards Institution	Design Investigation
Investigation of potentially contaminated sites – Code of practice	BS 10175: 2011+A2:2017	British Standards Institution	Supplementary Investigation
Land contamination risk management	Online resource, updated April 2021	Environment Agency	Stage 1 Risk Assessment: Tier 2: Generic quantitative risk assessment

Table 1-A: Definition of investigation scope

1.4 Limitations

- 1.4.1 Soiltechnics disclaims any responsibility to our Client and others in respect of any matters outside the scope of this report. This report has been prepared with reasonable skill, care and diligence in accordance with the terms of our contract, taking account of the resources, investigations and testing devoted to it by agreement with our Client. This report is confidential to our Client and Soiltechnics accepts no responsibility of whatsoever nature to third parties to whom this report or any part thereof is made known. Any such party relies upon the report at their own risk.

2 Existing Ground Investigations

2.1 Sources of information

2.1.1 Previous investigations have been undertaken at the site, reported as follows;

- Land at Trows Farm, Castleton: Ground Investigation (Smith Grant LLP, September 2017)
Document reference: R2392-R01-v2
- Cowm Top, Castleton: Preliminary Phase I & II Contamination and Geotechnical Assessment (Smith Grant LLP, February 2021)
Document reference: R2228-R02-v3
- Trows Farm: Investigation and monitoring of site water seepages (RSK, May 2020)
Document reference: 11440 L01

2.1.2 A summary of the relevant geo-environmental findings from the three previous reports listed above is discussed further in the proceeding sections.

2.1.3 We recommend our report is not read in isolation to the above reports.

2.2 Ground Investigation Report (R2392-R01-v2)

2.2.1 The report details the factual ground investigation works undertaken by Smith Grant LLP. The report refers to previous consultancy work undertaken by Smith Grant LLP, specifically a Stage 1 Geo-environmental Appraisal (Ref R2228-R01-v01, January 2016) and a Preliminary Phase I and II Contamination and Geotechnical Assessment (Ref: R2228-R02-v2). Soiltechnics have not had the opportunity to review either report but note that a later revision of the Phase I and II report is available and has been reviewed as part of this commission. Accordingly, it is considered that little benefit will be gained by reviewing those reports.

2.2.2 This ground investigation undertaken by Smith Grant LLP was carried out in two phases: June 2016 and May 2017. The scope of works can be broadly summarised as follows:

- 10 no. cable percussive boreholes drilled to a maximum depth of 20.45m;
- 13 no. dynamic windowless sample boreholes drilled to a maximum depth of 6.45m;
- 21 no. machine excavated trial pits to a maximum depth of 3.40m;
- 13 no. super heavy dynamic probes; and
- Laboratory testing.

2.3 Preliminary Phase I & II Contamination and Geotechnical Assessment (R2228-R02-v3)

2.3.1 This report presents the initial desk study findings which concluded that the site has only been previously agricultural in usage and there was limited potential for land contamination issues across the site.

2.3.2 Subsequent ground investigation across the site generally correlated with the initial findings with the exception of discrete small-scale areas of tipping of ashy and industrial type materials in three areas (refer to Smith Grant Drawing 001 presented in Appendix A).

2.3.3 A more widespread area of Made Ground was encountered in the southeast of the site adjacent to the A627(M) motorway, up to 5.8m deep. The Made Ground in this area was noted to comprise reworked natural soils and is highly likely to be related to cuttings to facilitate the development of the motorway. As such soils are reworked natural materials, the potential for contamination was concluded to be low.

2.3.4 Laboratory testing of selected Made Ground (4 No.) and Topsoil (6 No.) samples confirmed no presence of highly mobile contaminants and a low likelihood of contamination associated with the site and proposed residential end use (elevated lead, arsenic and high end TPH in Made Ground locally in 2 No. samples of Made Ground). In addition, 3 No. groundwater samples were analysed, which indicated a minor exceedance of chromium from one of the surface springs onsite when compared to surface water guidelines. Again, given the limited sources it was determined that such contamination was unlikely to pose risks to controlled waters and may be natural in origin.

2.4 Investigation and monitoring of site water seepages (11440 L01)

2.4.1 This letter report by RSK presents the findings of an investigation into the surface water seepages present at the site. The report presents an initial desk study element and makes reference to several spring lines identified on Ordnance Survey maps.

2.4.2 A site walkover identifies two valley features orientated approximately northeast to southwest and located within the western and eastern halves of the site. A site drainage survey concluded that these valleys drain to a pond south of Trows Lane and a further pond south of the site respectively.

2.4.3 Seepage flow rates are indicated to be low and the report further suggests that existing drainage techniques will be able to control the flows with relative ease.

2.4.4 Flow monitoring undertaken concluded that groundwater flow shows no obvious correlation with rainfall. However, the report caveats this by noting that the monitoring was over a relatively short period of time.

2.4.5 The report also covers a period of groundwater monitoring of boreholes installed as part of the Smith Grant intrusive investigation. These monitoring readings have been digitised and incorporated within the project dataset presented in latter sections of this report.

2.5 Anticipated Ground Model

2.5.1 Based on the previous phases of ground investigations completed to date ground conditions are generally expected to comprise topsoil overlying natural superficial deposits of Hummocky Glacial deposits, with localised occurrences of Made Ground and Alluvium. An overview of each anticipated stratum is presented below.

2.6 Topsoil

2.6.1 A nominal thickness of Topsoil is present across the site and is estimated to be 0.40m thick. Relict Topsoil is present at depth in the south-eastern area of the site where it is conjectured that minor earthworks have been undertaken to locally raise levels.

2.7 Made Ground

- 2.7.1 Made Ground was recorded in several exploratory holes across the site. The depth varied across the site with a maximum depth of 5.40m recorded within WS13 in the south-eastern corner. It is anticipated that this relates to general filling operations to raise ground levels. Only nominal compactive effort has been used when placing the material.
- 2.7.2 Isolated discrete lenses of ashy and inert materials were also identified in three locations on site – two in the north of the site, and a larger area to the north of the existing Trows Farm in the southwest of the site.

2.8 Alluvium

- 2.8.1 Alluvium is present in the two valley floors trending through the site in an approximately northeast-southwest direction. The material was generally encountered as a very soft clay and loose silty sand. The maximum depth to the base of the Alluvium is interpreted to be circa 2.00m based on dynamic probing results.

2.9 Hummocky Glacial Deposits

- 2.9.1 Hummocky Glacial Deposits underlie the entire site and the composition is highly variable. These deposits primarily comprise interdigitated layers of sand and silt but clay and occasional gravel bands are also recorded. The deposits extend to a depth in excess of 20m BGL. There is no apparent consistency of the individual layers across the site.

2.10 Groundwater

- 2.10.1 Groundwater is anticipated to be present within the more permeable bands of the Hummocky Glacial Deposits and constrained by the less permeable bands. This is evident in the three springs identified at the site on Ordnance Survey mapping and further two springs identified on the other side of the A627(M).
- 2.10.2 A summary of groundwater levels monitored at the site is presented below. The considerable gap in data from the installation of the standpipes in June 2017 by Smith Grant, completion of the monitoring by RSK in March 2020, and the monitoring undertaken by Soiltechnics in January 2023 (as part of slope stability analysis works). It should be noted that BHG was not serviceable during the periods of monitoring undertaken. On the whole the readings show relative consistency across the dates. However, a notable higher reading (circa 3m) was recorded in BHL in February 2023. No other standpipe showed such variation on the same day. On this basis it could represent an anomalous reading (due to human/instrument error for example) or could represent a localised area very responsive to rainfall events.

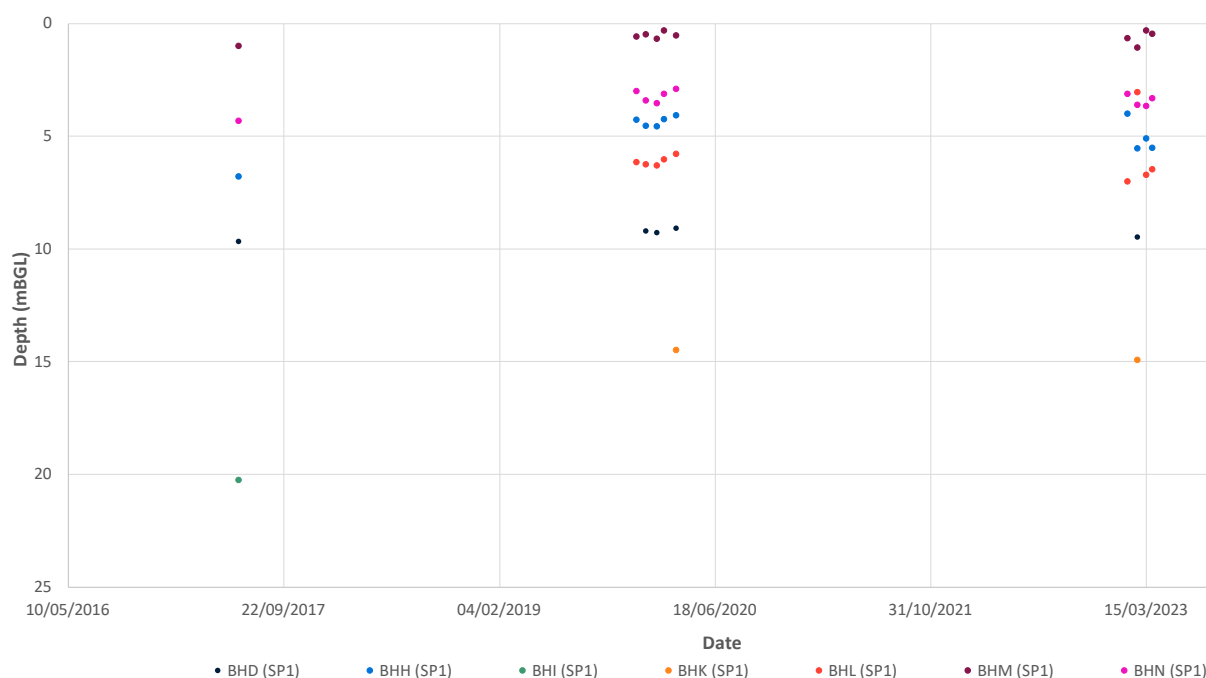


Figure 2-A: Summary of monitored groundwater depths at the site

2.11 Further Investigation

- 2.11.1 On the basis of the previous investigations and revised cut-and-fill drawings to facilitate a suitable development platform, supplementary ground investigation works are required to fully characterise current ground conditions.
- 2.11.2 From cut-and-fill proposals it is currently understood that excavation of peaks across the site of up to 9-10m below existing ground levels is proposed, with subsequent filling of valleys up to 11-12m in some areas. A copy of the proposed cut-and-fill drawing is presented in Appendix A.
- 2.11.3 A summary of the recommended further investigation works is presented below:
- Further delineation and chemical assessment of the identified Made Ground areas as well as a more detailed assessment of the existing topsoil resources for chemical suitability of reuse.
 - Ground gas risk assessment of migration of off-site landfill gases associated with a mapped historical landfill 40m northwest of the site.
 - Classification and characterisation of soils to be excavated and assessment of geotechnical suitability for reuse in areas of fill.

3 Supplementary Ground Investigation

3.1 Objectives

- 3.1.1 The supplementary ground investigation scope and location of exploratory holes was determined by Soiltechnics Ltd, based upon our overall brief outlined in Section 1.
- 3.1.2 The objectives of the fieldwork were to:
- i) Establish ground and groundwater conditions at the site.
 - ii) Obtain samples for subsequent laboratory testing.
 - iii) Install gas and groundwater monitoring wells and undertake a programme of monitoring visits.

3.2 Fieldwork Summary

3.2.1 Fieldwork was undertaken between Monday 15th July and Friday 26th July 2024.

3.2.2 A summary of the works completed is set out in the table below, along with the location of the exploratory logs. Photographic records of the boreholes and trial pits are presented in Appendix D, and the exploratory hole location plan is presented within Drawings 01A and 01B presented in Appendix A. General site images are also presented in Appendix D. It should be noted that the site has not changed since completion of previous investigations by others, and reference should be made to such reports to understand the overall arrangement of the existing site.

Exploratory Hole Logs	Method	Qty	Final Depth Range (m bgl)	Comments
Appendix B	Machine-excavated trial pits	26	1.20 – 3.50	TP01-TP15, TP17-TP19 & TP23-TP26. Trial pits terminated at scheduled depth.
			2.30 – 4.90	TP16, TP20-TP22. Trial pits terminated due to instability/collapse.
		17	0.30	SL01 - SL17 Trial pits terminated at scheduled depth.
Appendix C	Dynamic windowless sampling boreholes	4	5.45	WLS01 to WLS04. Boreholes terminated at scheduled depth.
Appendix C	Cable percussion boreholes	11	15.45	BH01 to BH11 Boreholes terminated at scheduled depth.

Table 3-A: Summary of fieldwork undertaken

3.2.3 All soils encountered were described in accordance with BS EN ISO 14688 “Identification and Classification of soil”.

3.3 Underground Infrastructure

- 3.3.1 Copies of all utility plans obtained are presented as Appendix J. The plans are provided for information only and should not be relied upon to be accurate. In addition, it is worth noting that the public utility plans provided by the asset owners typically exclude private service runs.
- 3.3.2 A large diameter gas main is present in the west of the site, with overhead and underground electric bales in the east of the site.

3.4 Unexploded Ordnance (UXO)

3.4.1 The site was assessed to have a low risk of encountering UXO and were supervised by a site engineer who has had UXO awareness training.

3.4.2 No items of suspected UXO were observed during fieldworks.

3.5 Sampling

3.5.1 During the fieldwork, sampling of soil for geotechnical purposes has been undertaken in accordance with BS EN ISO 22475-1 *“Geotechnical Investigation and testing – sampling by drilling and excavation and groundwater measurements”*.

3.5.2 Samples collected for chemical analysis have been taken and handled in accordance with BS ISO 18400-105:2017 *“Soil quality — Sampling Part 105: Packaging, transport, storage and preservation of samples”*.

3.5.3 Various sampling and sub-sampling methodologies have been adopted as appropriate, with the primary aim of obtaining the highest quality sample class practicable.

3.5.4 Untested chemical and geotechnical samples will be held for a period of 4 weeks from the date of the first report issue, after which they will be disposed of.

3.6 In-situ Testing

3.6.1 The following table summarises the field testing carried out. The results are summarised on individual exploratory hole logs where appropriate and detailed within the Appendices indicated.

Tests	Qty	Applicable standard / guidance	Location of Results
Standard penetration test (SPT)	121	BS EN ISO 22476-3	Included within logs Detailed in Appendix E
Hand shear vane	87	Manufacturer’s instructions	Included within logs Detailed in Appendix E
Pocket penetrometer	36	Manufacturer’s instructions	Included within logs Detailed in Appendix E

Table 3-B: Summary of field testing undertaken

3.7 Monitoring Installations

3.7.1 Instrumentation installed within exploratory holes during the fieldwork are shown on the logs within Appendix B and are summarised below:

Installation type	Target Stratum	Qty	Exploratory hole ID
Gas monitoring well	Hummocky Glacial Deposits	4	WS01 – WS04
Groundwater well	Hummocky Glacial Deposits	11	BH01 – BH11
Groundwater Monitoring well (Smith Grant)	Hummocky Glacial Deposits	8	BHD, H, I, K, L, M and N

Table 3-C: Summary of monitoring installations

3.8 Monitoring Visits

- 3.8.1 A summary of the gas and groundwater spot monitoring visits undertaken to date is outlined in the table below. Results of the post fieldwork monitoring are presented in Appendix F.
- 3.8.2 Continuous groundwater monitoring will be ongoing until August 2025 and all results will be included within the final version of the report.

Date	Purpose
01/08/2024	Installation of continuous groundwater monitoring equipment
09/08/2024	Gas and Groundwater spot monitoring, Installation of continuous groundwater monitoring equipment in BHM
30/08/2024	Gas and groundwater spot monitoring, continuous groundwater monitoring data collection
27/09/2024	
24/10/2024	
28/11/2024	

Table 3-D: Summary of post fieldwork spot monitoring

3.9 Continuous Groundwater Monitoring

- 3.9.1 In order to determine the seasonal groundwater fluctuations across the site, groundwater level data loggers were installed which are capable of providing continuous groundwater monitoring data. In addition to the data loggers, a barometer was installed on site to allow data to be compensated against atmospheric pressure changes.
- 3.9.2 The following table summarises the dataloggers installed on site to date, and the results are presented within Appendix F.
- 3.9.3 Presented alongside the groundwater trend lines is daily rainfall data from a nearby weather station, obtained from online rainfall databases.

Monitoring Well	Start Date	Reading Frequency	Monitoring Duration
BH01	01/08/2024	Every 15 minutes	1 year
BH02			
BH03			
BH04			
BH05			
BH05 (Barometer)			
BH06			
BH07			
BH08			
BH09			
BH10			
BH11			
BHD			
BHH			
BHI			
BHK			
BHL			

Monitoring Well	Start Date	Reading Frequency	Monitoring Duration
BHM	09/08/2024		
BHN	01/08/2024		

Table 3-E: Summary of groundwater level data loggers

3.10 Investigation Constraints

3.10.1 Boreholes BH01 and BH04 was relocated due to the steep slope leading up to the position with the new location moved to lower levels of the slope where access could be gained. No other investigation constraints were encountered which limited the scope of the works.

4 Laboratory testing

4.1 Overview

- 4.1.1 Samples obtained from exploratory holes were sent to independent accredited laboratories for geotechnical and chemical testing.

4.2 Geotechnical Testing

- 4.2.1 The geotechnical testing schedule was prepared by Soiltechnics using a targeted and judgemental approach, based upon the scheme proposals and our initial understanding of the ground conditions.
- 4.2.2 Geotechnical laboratory test results are presented in Appendix G, and the total number of geotechnical tests undertaken is summarised below:

Qty	Test
57	Moisture content
57	Atterberg limits
73	Particle size distribution (coarse)
73	Particle size distribution (fines)
22	CBR test (remoulded)
33	Single stage undrained shear strength in triaxial compression
21	Dry density / Moisture content relationship
22	Shear strength of a set of three 60mm × 60mm square specimens by direct shear
22	Moisture Condition Value / Moisture content relationship
34	BRE SD1 Suite B

Table 4-A: Summary of geotechnical laboratory testing

4.3 Chemical Testing

- 4.3.1 The chemical testing schedule was prepared by Soiltechnics using a targeted and judgemental approach, based upon the initial conceptual site model and fieldwork observations. This is further elaborated on within subsequent report sections.
- 4.3.2 Chemical laboratory test results are presented in Appendix H, and the total number of chemical tests undertaken is summarised below:

Sample Type	Qty	Testing	Suite Name
Topsoil	40	Basic Classification Suite [metals, cyanides, PAHs, phenol, banded TPH & asbestos]	Basic Classification Suite
Made Ground	10	Basic Classification Suite [metals, cyanides, PAHs, phenol, banded TPH & asbestos]	Basic Classification Suite
	2	Asbestos quantification (on a tested positive sample)	Asbestos quantification

Table 4-B: Summary of chemical laboratory testing

5 Ground Investigation Findings

5.1 Ground Model

- 5.1.1 Ground conditions encountered were relatively consistent with previous ground investigation findings. Detailed photographic records of soils encountered within exploratory locations are presented in Appendix D.
- 5.1.2 The tables below present our generalised interpretation of geological and hydrogeological conditions at the site. Unless otherwise stated in subsequent interpretive report sections, this represents the adopted ground model.
- 5.1.3 Further detail about the ground conditions encountered is provided in the relevant sub-sections below.

Stratum	Brief description	Top depth range (m bgl)	Adopted model top depth (m bgl)	Thickness (m)
Topsoil	Dark brown sandy gravelly clay or clayey gravelly sand.	G.L.	G.L.	0.20 to 0.40
Made Ground	Firm sandy gravelly clay with brick, concrete, coal and occasional timber/fragments (SE corner of site).	0.20 to 0.40	0.30	0.45 to 2.50
	Soft grey gravelly clay with occasional brick (TP19 & TP20 only, north of Trows Farm).			1.05 to 1.40
	Black silty sandy gravel of clinker, brick and ceramic (TP01, TP03, NE corner of site).			0.30 to 1.10
Alluvium (TP17, TP19 & TP20 only)	Soft dark grey sandy silt.	0.30	-	0.55 to 0.60
Hummocky Glacial Deposits	Interbedded gravelly sands, silts and clays.	0.20 to 1.60	0.50	>15.15

Table 5-A: Ground model

5.2 Topsoil

- 5.2.1 Topsoil was encountered in all exploratory holes typically 0.2m-0.4m thick.
- 5.2.2 The composition of the Topsoil encountered was variable across site, consisting of either organic clayey gravelly sand or organic sandy gravelly clay. Rare anthropogenic inclusions were noted including brick and ceramic.
- 5.2.3 A photograph of topsoil deposits encountered is presented below.



Figure 5-A: Sandy Topsoil deposits encountered in TP21



Figure 5-B: Clayey Topsoil deposits encountered in TP09

5.3 Made Ground

- 5.3.1 Localised Made Ground was encountered within the areas southeast, northeast and west of the site, consistent with previous ground investigations. The areas are defined on Drawing 01A/B. A very localised area immediately at surface was also encountered in the area of SL02.
- 5.3.2 In the south-eastern area of the site, the base of the Made Ground was encountered between depths of 0.70m (TP14) and 2.80m BGL (TP11) and varied between 0.45m and 2.50m in thickness. The Made Ground largely comprised sandy gravelly clay with brick, concrete, coal with timber and ceramic fragments, and is anticipated to comprise reworked material sourced from the formation of the adjacent A627(M).

5.3.3 A photograph of the Made Ground encountered in the southeast of the site is presented below.



Figure 5-C: Made Ground encountered in TP10

5.3.4 Made Ground was also encountered in the northeast of the site within TP01 and TP03. The base of the unit was located between depths of 0.60m and 1.30m BGL and varied between 0.30m and 1.10m in thickness.

5.3.5 The Made Ground encountered consisted of silty sandy cobbly gravel of clinker, ceramic, glass, metal and brick fragments. A hydrocarbon odour was noted between depths of 1.10-1.30m BGL in TP03.

5.3.6 A photograph of the Made Ground from the north-eastern area of the site is presented below.



Figure 5-D: Made Ground encountered in TP03

- 5.3.7 Made Ground was also encountered in the south-western area of the site within TP19 & TP20. The base of the unit was located between depths of 1.05m and 1.40m BGL, with no topsoil overlying.
- 5.3.8 The Made Ground varied between the two positions, consisting of gravels of brick, clicker, glass, ceramic, timber and metal fragments within TP19, and clay with brick and plastic fragments within TP20.
- 5.3.9 A photograph of the Made Ground encountered within the south-western area of the site is presented below.



Figure 5-E: Made Ground encountered in TP19

5.4 Alluvium

- 5.4.1 Alluvium was encountered within the western valley floor in TP17, TP19 and TP20. The base of the Alluvium was recorded as 0.9m and 1.6m in TP17 and TP19 respectively but was not encountered in TP20 where the maximum excavation depth was 2.30m.
- 5.4.2 The Alluvium encountered typically consisted of soft dark grey/brown sandy gravelly silt. Deposits were also encountered in the eastern valley area during previous ground investigations by Smith Grant LLP.
- 5.4.3 A photograph of the Alluvium encountered is presented below.



Figure 5-F: Alluvium deposits encountered in TP20

5.5 Hummocky Glacial Deposits

- 5.5.1 Hummocky Glacial Deposits were encountered in every exploratory position beyond the maximum excavation depth of 15.45m BGL.
- 5.5.2 The Hummocky Glacial Deposits encountered had variable composition site-wide, consisting of interbedded layers of fine-grained clay materials and coarse-grained sand materials. Boreholes in the centre and south of the site (BH03-BH05, BH07, BH08 and BH11) generally recorded dominantly coarse-grained materials with some lenses of fine-grained clays, whereas BH01, BH02 and BH10 in the north and east, as well as BH09 in the southwest recorded generally fine-grained materials with lenses of coarse-grained sand, generally at greater depth.
- 5.5.3 A series of photographs of the Hummocky Glacial Deposits encountered are presented below.



Figure 5-G: Hummocky Glacial Deposits consisting of gravelly sands encountered in TP16

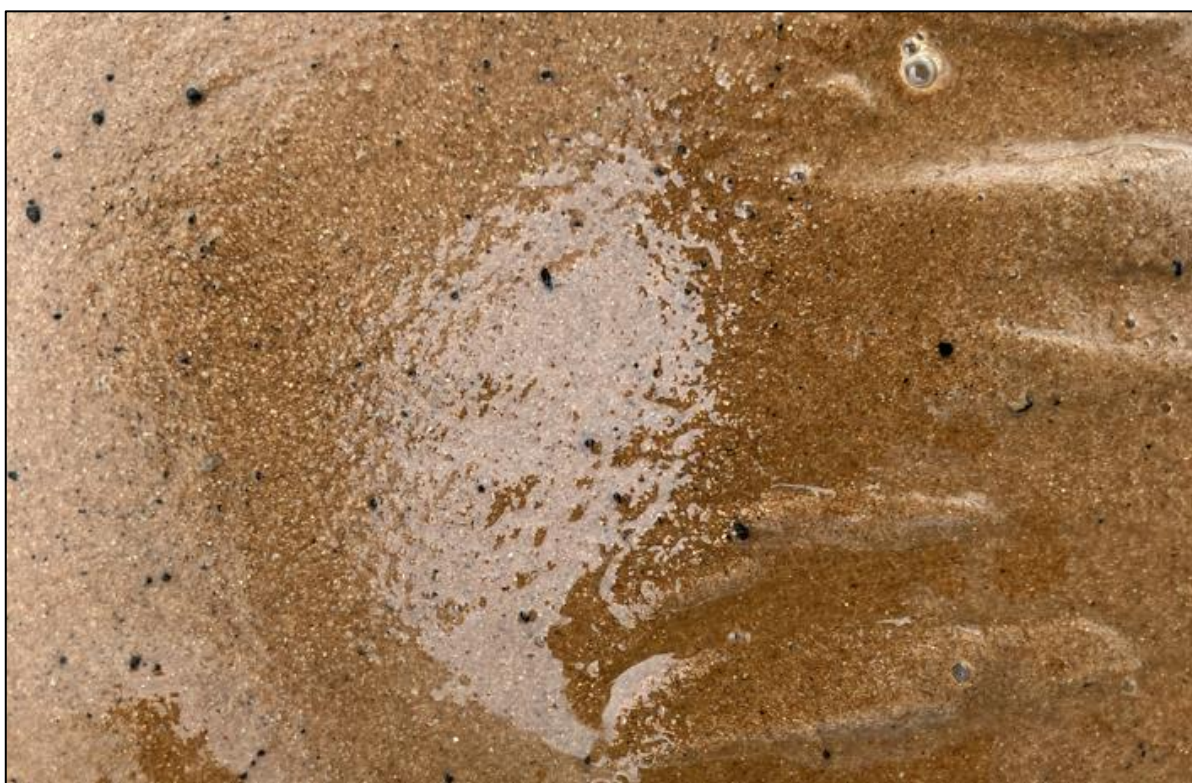


Figure 5-H: Hummocky Glacial Deposits consisting of gravelly sands encountered in BH08



Figure 5-1: Hummocky Glacial deposits consisting of clay encountered in TP26

5.6 Groundwater

5.6.1 A summary of the groundwater level data obtained during the fieldworks phase is presented below.

Exploratory hole ID	Groundwater observation
BH02	Groundwater strike at 15.0m, rising to 12.4m after 20 minutes.
BH03	No groundwater strike recorded however groundwater recorded resting at 7.4m upon start of next day's shift
BH05	Groundwater strike at 13.5m, rising to 12.0m after 20 minutes.
BH06	Groundwater strike at 8.6m, rising to 7.5m after 20 minutes. Groundwater rising to 5.0m overnight.
BH10	Groundwater strike at 12.5m, remaining steady after 20 minutes.
BH11	Slow seepage of groundwater encountered below 13.0m.
TP17	Slow seepage at 2.0m.
TP20	Slow seepage at 1.95m.

Table 5-B: Summary of groundwater observations during the fieldworks

5.6.2 A summary of the groundwater level data obtained during the monitoring phase is presented below, and is detailed within Appendix F.

Targeted strata / Aquifer	Exploratory hole ID	Instrument Type(s)	Range during monitoring period	
			Water depth (m bgl)	Water level (m AOD)
Hummocky Glacial Deposits	BH01	Logger	Dry	Dry
	BH02	Logger	8.464 – 9.443	168.085 – 169.064
	BH03	Logger	7.057 – 7.549	169.050 – 169.542
	BH04	Logger	Dry	Dry

Targeted strata / Aquifer	Exploratory hole ID	Instrument Type(s)	Range during monitoring period	
			Water depth (m bgl)	Water level (m AOD)
	BH05	Logger	8.513 – 8.915	167.398 – 167.800
	BH06	Logger	5.401 – 5.960	165.323 – 165.882
	BH07	Logger	1.976 – 2.961	163.973 – 164.958
	BH08	Logger	11.400 – 11.994	155.450 – 156.039
	BH09	Logger	9.828 – 10.867	153.437 – 154.476
	BH10	Logger	11.058 – 11.253	153.304 – 153.499
	BH11	Logger	1.523 – 2.069	154.367 – 154.913
	BHD	Logger	Dry	Dry
	BHH	Logger	6.590 – 7.162	169.003 – 169.575
	BHI	Logger	Dry	Dry
	BHK	Logger	6.609 – 6.862	164.658 – 164.911
	BHL	Logger	Dry	Dry
	BHM	Logger	0.626 – 1.995	162.629 – 163.998

Table 5-C: Summary of groundwater monitoring visits

- 5.6.3 BHN had slitted up significantly between install and end of November and was therefore giving anomalous readings. The datalogger was removed and reinstalled at the end of November at a shallower depth above the silted-up zone.
- 5.6.4 Continuous groundwater monitoring has been ongoing for 4 months to date. Another 7-8 months of continuous groundwater monitoring is scheduled and the final report will be updated on completion.
- 5.6.5 Shallow groundwater was recorded between depths of 0.38-0.9m BGL in ground gas monitoring wells during 2 of 5 rounds in WS02 and WS03 and in all 5 rounds in WS04 in the northwest corner of the site. It is anticipated that these groundwater levels relate to perched groundwater within more granular superficial deposits, and are not expected to be representative of the groundwater table.
- 5.6.6 Groundwater levels are expected to vary seasonally and in response to recent weather conditions. Long term monitoring will provide a reasonable quantification of such variation.

5.7 Evidence of Possible Contamination

- 5.7.1 Other than general anthropogenic material contained in Made Ground in localised areas of the site, the table below summarises the potential contamination noted during the ground investigation works.

Exploratory hole ID / Area	Depth of observation (m bgl)	Stratum	Description
TP03	1.10	Made Ground	Hydrocarbon Odour

Table 5-D: Summary of potential contamination noted during the investigation works

5.8 Obstructions and Instability

- 5.8.1 The table below summarises the obstructions and instability encountered that affected the progress of the investigation works.
- 5.8.2 The general stability of trial pits during excavation are also recorded on the trial pit logs.

Strata / Area	Depth range (m bgl)	Issue	Description
Hummocky Glacial Deposits	2.50 – 4.90	Instability	TP16, TP20-TP22. Terminated due to collapse of sand strata.

Table 5-E: Summary of instability encountered during the investigation works

5.8.3 Obstructions were not encountered during the investigation works.

6 Geotechnical Discussion

6.1 Scheme Overview

- 6.1.1 The following assessments are made on the investigatory data presented in the preceding sections of this report and are made with reference to the specific nature of the development. Should scheme proposals change then it is recommended that the validity of the conclusions of this report in relation to the revised scheme are checked.
- 6.1.2 The project will comprise the cut and fill of levels sitewide and the construction of low-rise dwellings, associated highways and soft landscaping and attenuation basins.
- 6.1.3 The overall scheme comprises construction of 445 No. low rise residential dwellings, with associated highways, gardens/soft landscaping and attenuation basins. As part of the scheme, earthworks reprofiling will be undertaken to allow development, comprising cut in areas of up to 9m bgl, and filling of up to 10m in other areas. Current development layouts are presented in Appendix A.
- 6.1.4 According to the preliminary cut and fill drawing presented in Appendix A, it is estimated that 323,009m³ of soil will be cut from site, and 223,093m³ will be required as fill; generating an excess of approximately 99,916m³. This excess will be further increased by arisings generated from foundation/service/ highway excavations. It is anticipated that approximately 112,439m³ of Topsoil is currently on site; although it is understood that some of this material will be exported from site during development.
- 6.1.5 In view of the scheme proposals, the geotechnical elements considered in this report are outlined below:
- Building foundations
 - Drainage
 - Slope stability
 - Retaining walls
 - Pavement
 - Floor slabs

6.2 Geotechnical Category

- 6.2.1 In accordance with BS EN1997-1:2004 + A1:2013 (Eurocode 7), the project is designated as Geotechnical Category 2. This category includes projects with *conventional types of structures and foundations with no exceptional risk, or difficult ground or loading conditions*. Furthermore, *routine design procedures* are appropriate.
- 6.2.2 It should be noted that this Report does not constitute a Geotechnical Design Report (GDR) as defined in Eurocode 7. Accordingly, a GDR should be prepared by the designer during the detailed design phase

6.3 Key Geotechnical Issues

- 6.3.1 In view of the ground conditions, the following list summarises the key geotechnical issues that may impact the scheme and will therefore need to be appropriately managed during the lifecycle of the project:

- Deep Fill Material and Made Ground
- Groundwater
- Trees and other vegetation

6.4 Deep Fill Material and Made Ground

- 6.4.1 Extensive cut and fill is required across the site to facilitate development, with up to 9m of cut and 10m of fill expected. A cut-and-fill drawing overlaid on an exploratory hole plan and development proposals is included in Appendix A.
- 6.4.2 Where cutting or <1m of fill is expected, shallow spread foundations within proposed dwellings are expected to be suitable, subject to penetration of the natural soils by 0.3m. Made Ground has been encountered to depths between 0.70m to 2.8m BGL in the southeast of the site, 0.6m to 1.3m BGL in the northeast of the site, and 1.05m to 1.40m BGL in the southwest of the site. Foundation excavations will need to penetrate such soils where left in situ during earthworks. Consideration will also need to be given to the consolidation of such deposits if large volumes of fill are placed above. Generally, based on current proposals, cut is proposed in areas of Made Ground, therefore the likelihood of significant consolidation settlement manifesting is considered low.
- 6.4.3 Where >2m of fill is expected to be present, piled foundations are expected to be required. Alternatively, engineering and validation of the proposed fill may allow for the use of raft foundations, as well as reducing the risk associated with differential settlement.

6.5 Alluvium

- 6.5.1 Alluvium was encountered locally in the western valley floor area (TP17, TP19 and TP20). In addition, the likely extents of Alluvium present in the western and eastern valley areas, as defined by Smith Grant during previous investigations, is illustrated on Drawing R2392-001 presented in Appendix A.
- 6.5.2 Such deposits will not provide suitable support to traditional foundations. Based on cut and fill drawings in Appendix A, there is a significant amount of fill proposed in such areas, and therefore foundations (other than piles) are unlikely to come into contact with such soils. Consideration will, however, need to be given to the consolidation of such deposits where large volumes of fill are placed above. Excavation and placement elsewhere onsite, or offsite disposal, could be considered.

6.6 Groundwater

- 6.6.1 It is anticipated that groundwater may be encountered during foundation excavations, however, will be dependent on finished ground levels following cut/fill and type of foundation required.
- 6.6.2 Based on the continuous monitoring plots presented in Appendix F, groundwater levels are very consistent in each area of the site, with a quick response to rainfall events noted (within 24hrs) in data. Groundwater then appears to reach a level of equilibrium within a few days. BHM, positioned in the eastern part of the site, shows the most prominent response to rainfall and more lengthy return to equilibrium (within 5-7 days in some instances). The well has been installed within largely fine grained deposits with occasional lenses (0.5m to 1m thick) of sand, which is consistent with flow dissipating at a slower rate.
- 6.6.3 Based on water levels measured to date, groundwater flow is generally funnelled to the southeast and southwest along the existing valleys. This is illustrated in Drawing D03 in Appendix A.

6.6.4 Given the extent of earthworks proposed at the site, groundwater levels measured to date have been analysed against proposed cut and fill levels. The table below presents data collected to date. It is noted that proposed cut levels are below the groundwater table in 3 No. areas of the site. In the areas of BH07 (south central part of site), and BHH (central plateau), groundwater is ~1m above the cut level proposed, and is still above the cut level when factoring in the fluctuation in groundwater levels measured to date. It is also noted that groundwater in boreholes BH03 and BH05 located either side of BHH on highest plateau (and where most significant cut is proposed), was measured ~0.5m to 1.0m below proposed cut levels (~1-1.5m with fluctuations noted).

6.6.5 Depth of proposed cut is most notably below measured groundwater levels in the area of BH11 in the southern part of the site, which reaches up to 2m below water (1.5m with groundwater fluctuation measured to date).

Borehole	Ground level (mAOD)	Deepest groundwater level (mAOD)	Shallowest groundwater level (mAOD)	Groundwater depth fluctuation (m)	Depth of cut (m bgl)	Depth of cut (mAOD)	Cut below/above groundwater level (m)
BH01	170.497	Dry	Dry	N/A	Fill	N/A	N/A
BH02	177.528	168.085	169.064	0.979	3	174.528	5.464
BH03	176.599	169.05	169.542	0.492	6	170.599	1.057
BH04	152.99	Dry	Dry	N/A	Fill	N/A	N/A
BH05	176.313	167.398	167.8	0.402	8	168.313	0.513
BH06	167.875	165.323	165.882	0.559	0.5	167.375	1.493
BH07	166.934	163.973	164.958	0.985	3	163.934	-1.024
BH08	167.444	155.45	156.039	0.589	2	165.444	9.405
BH09	164.304	153.437	154.476	1.039	7.5	156.804	2.328
BH10	164.557	153.304	153.499	0.195	3	161.557	8.058
BH11	156.436	154.367	154.913	0.546	3.5	152.936	-1.977
BHD	163.287	Dry	Dry	N/A	Fill	N/A	N/A
BHH	176.165	169.003	169.575	0.572	7.5	168.665	-0.91
BHI	183.281	Dry	Dry	N/A	2.5	180.781	N/A
BHK	171.52	164.658	164.911	0.253	2.5	169.02	4.109
BHL	169.71	Dry	Dry	N/A	3.5	N/A	N/A
BHM	164.624	162.629	163.998	1.369	Fill	N/A	N/A
BHN	155.214	Reinstalled due to silt build up		N/A	3	152.214	N/A

Table 6-A: Details of groundwater levels relative to proposed cut/fill works

6.6.6 Consideration will need to be given the areas of the site where proposed cut levels are below groundwater levels, and the implications this will have on feasibility of such works. It is likely that proposed ground levels will need to be raised in such areas to ensure groundwater remains below surface level long term, or installation of an adequate permanent drainage solution to collect groundwater before it enters the site.

6.6.7 In all other areas of the site where groundwater has been measured to date, levels are well below proposed cut levels and worst case is ~1.5-2.0m below cut.

6.6.8 The inflow of groundwater into excavations will likely lead to instability and excavation collapse.

6.7 Trees and other Vegetation

- 6.7.1 It is anticipated that most if not all of the existing trees/vegetation will be removed as part of earthworks. Should any trees remain in close proximity of proposed dwellings, for example along site boundaries, these may impact upon the foundation design depth.
- 6.7.2 It is recommended that a suitably qualified arboriculturist is appointed to undertake a survey such that building foundations can be designed appropriately. The survey should include the location, species, height (and mature height) and water demand of each tree and major vegetation.
- 6.7.3 Any future planting schemes should consider the effect that the new trees could have on foundations when they reach maturity. Consideration will need to be given to use of clay soils during earthworks and placement in the vicinity of mature vegetation.

6.8 Building Foundation Strategy

- 6.8.1 In view of the key geotechnical issues discussed above and anticipated loadings the following foundation types are considered suitable for the project;
- Spread foundations
 - Raft in areas of fill (following ground improvement/engineering of earthworks)
 - Piles

6.9 Geotechnical Parameters

- 6.9.1 Characteristic values of geotechnical parameters have been derived, in accordance with Eurocode 7. The following tables present the recommended characteristic values for the strata encountered:

Variable	Characteristic value	Derivation
Weight density above water table, γ_b (kN/m ³)	19	BS8004:2015 Figure 1
Critical state angle of shearing resistance, ϕ_{cv} (°)	31	BS8004:2015 Equation 4

Table 6-B: Summary of characteristic geotechnical parameters – coarse-grained Hummocky Glacial deposits

Variable	Characteristic value	Derivation
Weight density above water table, γ_b (kN/m ³)	16	BS8004:2015 Figure 1
Undrained shear strength, c_u (kN/m ²)	33	In situ testing Laboratory testing
Critical state angle of shearing resistance, ϕ_{cv} (°)	27	Correlation with plasticity
Effective cohesion, c' (kN/m ²)	0	Conservative assumption
Undrained deformation modulus, E_u (MN/m ²)	12.5	$E_u/c_u = 375$ from Jamiolkowski et al (1979)

Table 6-C: Summary of characteristic geotechnical parameters – fine-grained Hummocky Glacial deposits

6.10 Spread Foundations

- 6.10.1 The fine-grained soils underlying the proposed foundations are of low to medium volume change potential when classified in accordance with NHBC Standards, Chapter 4.2. Accordingly, and in isolation of other considerations affecting foundation depth, foundations should be located at a minimum depth of 0.9m BGL to penetrate the zone of shrinkage and swelling caused by seasonal wetting and drying.
- 6.10.2 Where soils underlying the foundations are coarse-grained in nature and therefore are not shrinkable and thus their volume will not be influenced by the water demands of the variety of trees bordering the site. Accordingly, and in isolation of other considerations affecting foundation depth, foundations should extend a minimum of 0.75m below ground level.
- 6.10.3 Made Ground was encountered locally on site, and extensive earthworks are proposed sitewide. Where present near surface, all foundations should extend through Made Ground and into the underlying Hummocky Glacial deposits by a minimum of 0.3m.
- 6.10.4 Ultimate limit state analyses (bearing capacity) have been undertaken in accordance with the approach outlined in Annex D of Eurocode 7 to derive the following design bearing resistances. It should be noted that bearing capacities for both fine-grained and coarse-grained Hummocky Glacial Deposits have been calculated and the worst case values adopted below.

Type	Width (m)	Founding depth (m BGL)	Founding stratum	Bearing resistance	
				Combination 1	Combination 2
Strip	0.60	0.75/0.9	Hummocky Glacial Deposits	170kNm ⁻²	120kNm ⁻²
	0.90			170kNm ⁻²	120kNm ⁻²
	1.20			175kNm ⁻²	125kNm ⁻²

Table 6-D: Summary of foundation ultimate limit state analyses

- 6.10.5 Serviceability limit state (SLS) has been assessed by undertaking settlement analyses in accordance with the approach outlined in Annex F of Eurocode 7 and adopting the following variables:

Stratum	Variable	Value adopted	Derivation
Hummocky Glacial Deposits (fine-grained)	Coefficient of volume compressibility, m_v (m ² /MN)	0.2	Correlation with SPT N Value
	Geological factor, μ_g	0.7	Literature
Hummocky Glacial Deposits (coarse-grained)	SPT N Value	9	In situ testing

Table 6-E: Key geotechnical variables used in settlement analyses

- 6.10.6 The proposed loads are not known at this stage. Accordingly, the maximum bearing pressures have been derived to ensure settlement is less than 25mm, which is typically adopted as a maximum tolerable limit. The following table summarises the results.

Foundation type	Width (m)	SLS bearing resistance
Strip	0.60	120kNm ⁻²
	0.90	120kNm ⁻²
	1.20	100kNm ⁻²

Table 6-F: SLS bearing resistance to ensure total settlement to <25mm

6.10.7 It is anticipated that excavations to founding levels may encounter both fine grained and coarse grained soils. Whilst these soils will ultimately generate similar amounts of total settlement under applied foundation loads, the rate at which settlement will occur will differ. Granular soils will produce settlements almost immediately after loads are applied whereas fine grained soils continue to consolidate several years after completion of construction. Accordingly, traversing mixed soil types will be subject to differential settlement. To minimise the effects of such movement it is recommended that foundations are reinforced in such areas, and placement of soils of similar composition is considered during the earthworks to avoid such requirements.

6.10.8 It should be noted that foundation design is iterative. Accordingly, a final check of ultimate and serviceability limit states should be undertaken following confirmation of foundation size and loads.

6.11 Pile Resistance

6.11.1 In areas where fill depth exceeds 2m it is recommended that piled foundations (or a raft foundation following engineering of the fill material, see below) are adopted.

6.11.2 Given the number of plots that could require piling (some in excess of 10m deep) it is anticipated that engineering/ground improvement of fill material and adoption of a raft foundation will be more economically viable.

6.11.3 It is recommended if piled foundations are adopted, that a piling specialist is consulted to assess pile resistance on a plot-specific basis.

6.12 Raft

6.12.1 Should ground improvement or engineering of fill materials during placement be undertaken then raft foundations could be adopted for plots underlying more than 2m of fill materials.

6.12.2 Raft foundations have the ability to spread super structural loads over the footprint of the building thus substantially reducing stresses imparted to the ground compared with spread foundations transferring more concentrated loads to the ground. It is normal practice to limit plan lengths to a maximum of 1:2.

6.12.3 For the purposes of assessing potentially worst case settlement of raft foundations it is conservatively assumed that coarse-grained Hummocky Glacial deposits used as fill will be engineered to achieve an equivalent SPT N-value of 20. For the fine-grained Hummocky Glacial Deposits it is assumed that they can be engineered to have similar geotechnical properties to natural in-situ fine-grained materials (parameters presented in Table 6-C). It is also conservatively assumed that engineered fill materials will be a minimum 2m thick, underlain by undisturbed fine-grained Hummocky Glacial deposits.

6.12.4 Serviceability limit state governs raft design. Assuming the raft is designed to impose a uniformly distributed load of say 30kN/m^2 , then total settlement within coarse-grained engineered fill materials is unlikely to exceed 20mm, and within fine-grained engineered fill unlikely to exceed 25mm. Differential settlement is dependent upon variation of stresses imposed on soil and the compressibility characteristics of the soil. Assuming the soils are uniformly stressed (as a result of the raft being structurally stiff) then differential movements are unlikely to result in excessive tilt.

6.12.5 Local loss of support is considered a risk at this site, in a scenario where engineered soils are not adequately placed and compacted, or conditioning for reuse is not undertaken. Accordingly, it is recommended that the raft can accommodate a local loss of support of say 1.5m diameter.

6.12.6 Prior to construction of the raft, it is recommended that the formation is rolled using heavy compaction plant with a view to identify any surface 'soft' spots, which if found will require excavation and replacement with a well graded durable well compacted stone. Furthermore, it is good practice to install a blanket of suitably compacted granular fill below the raft or a blinding concrete to provide a construction platform.

6.13 Ground Improvement

6.13.1 Ground improvement is typically associated with increasing the strength and stiffness of the ground, thereby leading to increased bearing capacity and lower settlement. This has the consequential benefit that foundation designs can be leaner, economical and more sustainable.

6.13.2 There are many techniques associated with ground improvement and consultation with specialist contractors should be undertaken. The following table summarises the common techniques adopted and the relative advantages and disadvantages of each:

Technique	Overview	Advantages	Disadvantages
Dynamic compaction	Repeated dropping of large weights (10-20t) from a notable height (e.g. 10-20m).	Tried and tested technique. Can compact circa 5-6m.	Unsuitable for clayey soils. Induces notable ground vibration.
Vibro-compaction	Insertion of a poker into the ground which vibrates leading to settlement of overlying fill.	Densifies granular soils. Reduces risk of liquefaction and collapse settlement.	Unsuitable in clay soils Induces vibration.
Surcharging	Application of additional load to induce settlement before main construction phase.	Effects the soil uniformly. Applicable to all soil types.	Time consuming (weeks and month) but can be sped up through inclusion of vertical drains. Volume of surcharge material removed needs a receptor.
Controlled modulus columns	Installation of low strength concrete columns.	Effective up to tens of metres. Alternative option to driven piles.	Tight spacing required in very soft soils.
Soil mixing	A stabilising agent is (typically lime / cement) is mixed with the in situ soils to lower the water content	Effective up to 20m Can render unacceptable materials acceptable for use in earthworks.	Unsuitable in sulphide rich material due to formation of ettringite and consequential heave.
Grouting	Cement or polymer based grout is injected into the ground.	Minimal surface footprint required – can repair existing problems in situ.	Less suitable in clayey soils.

Table 6-G: Summary of common ground improvement techniques

6.14 Foundation Zoning

6.14.1 Based on the above, and considering the extent of cut and fill across the site, a plot-specific summary of the anticipated foundation requirements has been developed, and presented in the table below.

Plot No.:	Structure type:	Finished ground level max (change in elevation)	General ground conditions:	Depth to natural ground after earthworks (m bgl):	Foundation type		
					Shallow*	Alternative shallow**	Piled/Raft***
D001	Detached	-1.0	Granular	0.0	✓	✗	✗
D002	Semi-detached	-1.0	Granular	0.0	✓	✗	✗
D003	Semi-detached	0.0	Granular	0.0			
D004	Detached	0.0	Granular	0.0	✓	✗	✗
D005	Detached	1.0	Granular	1.0	✗	✓	✗
D006	Semi-detached	2.0	Granular	3.9	✗	✗	✓
D007	Semi-detached	3.0	Granular	4.9			
D008	Detached	4.0	Granular	5.9	✗	✗	✓
D009	Detached	7.0	Granular	8.9	✗	✗	✓
D010	Detached	8.0	Granular	9.9	✗	✗	✓
D011	Detached	8.0	Granular	9.9	✗	✗	✓
D012	Semi-detached	9.0	Granular	10.9	✗	✗	✓
D013	Semi-detached	9.0	Granular	10.9			
D014	Semi-detached	6.0	Granular	7.9	✗	✗	✓
D015	Semi-detached	4.0	Granular	5.9			
C1	Semi-detached	9.0	Granular	9.0	✗	✗	✓
C2	Semi-detached	9.0	Granular	9.0			
C3	Semi-detached	7.0	Granular	7.0	✗	✗	✓
C4	Semi-detached	5.0	Granular	5.0			
C5	Detached	1.0	Granular	1.0	✗	✓	✗
C6	Detached	9.0	Granular	9.0	✗	✗	✓
C7	Semi-detached	10.0	Granular	10.0	✗	✗	✓
C8	Semi-detached	10.0	Granular	10.0			
C9	Terraced	10.0	Granular	10.0	✗	✗	✓
C10	Terraced	10.0	Granular	10.0	✗	✗	✓
C11	Terraced	10.0	Granular	10.0	✗	✗	✓
B1	Detached	4.0	Interbedded	4.0	✗	✗	✓
B2	Detached	5.0	Interbedded	5.0	✗	✗	✓
B3	Semi-detached	7.0	Interbedded	7.0	✗	✗	✓
B4	Semi-detached	8.0	Interbedded	8.0			
B5	Detached	9.0	Interbedded	9.0	✗	✗	✓
B6	Detached	9.0	Interbedded	9.0	✗	✗	✓
B7	Semi-detached	8.0	Interbedded	8.0	✗	✗	✓
B8	Semi-detached	7.0	Interbedded	7.0			
B9	Detached	5.0	Interbedded	5.0	✗	✗	✓
B10	Semi-detached	4.0	Interbedded	4.0	✗	✗	✓

B11	Semi-detached	5.0	Interbedded	5.0			
B12	Detached	4.0	Interbedded	4.0	x	x	✓
B13	Semi-detached	4.0	Interbedded	4.0	x	x	✓
B14	Semi-detached	5.0	Interbedded	5.0			
B15	Detached	-1.0	Interbedded	0.0	✓	x	x
B16	Detached	0.0	Interbedded	0.0	✓	x	x
B17	Detached	2.0	Interbedded	2.0	x	x	✓
B18	Semi-detached	3.0	Interbedded	3.0	x	x	✓
B19	Semi-detached	3.0	Interbedded	3.0			
B20	Detached	3.0	Interbedded	3.0	x	x	✓
B21	Semi-detached	2.0	Interbedded	2.0	x	x	✓
B22	Semi-detached	2.0	Interbedded	2.0			
B23	Detached	3.0	Interbedded	3.0	x	x	✓
B24	Detached	3.0	Interbedded	3.0	x	x	✓
B25	Terraced	3.0	Interbedded	3.0	x	x	✓
B26	Terraced	3.0	Interbedded	3.0	x	x	✓
B27	Terraced	3.0	Interbedded	3.0	x	x	✓
B28	Detached	7.0	Interbedded	7.0	x	x	✓
B29	Detached	7.0	Interbedded	7.0	x	x	✓
B30	Semi-detached	7.0	Interbedded	7.0	x	x	✓
B31	Semi-detached	7.0	Interbedded	7.0			
B32	Detached	7.0	Interbedded	7.0	x	x	✓
B33	Detached	6.0	Interbedded	6.0	x	x	✓
B34	Detached	8.0	Interbedded	8.0	x	x	✓
B35	Detached	8.0	Interbedded	8.0	x	x	✓
B36	Detached	7.0	Interbedded	7.0	x	x	✓
B37	Detached	8.0	Interbedded	8.0	x	x	✓
B38	Semi-detached	7.0	Interbedded	7.0	x	x	✓
B39	Semi-detached	7.0	Interbedded	7.0			
B40	Detached	7.0	Interbedded	7.0	x	x	✓
B41	Semi-detached	6.0	Interbedded	6.0	x	x	✓
B42	Semi-detached	6.0	Interbedded	6.0			
B43	Detached	9.0	Granular	9.0	x	x	✓
B44	Detached	9.0	Granular	9.0	x	x	✓
B45	Detached	10.0	Granular	10.0	x	x	✓
B46	Detached	9.0	Granular	9.0	x	x	✓
B47	Semi-detached	6.0	Interbedded	6.0	x	x	✓
B48	Semi-detached	6.0	Interbedded	6.0			
B49	Detached	4.0	Interbedded	4.0	x	x	✓
B50	Detached	3.0	Interbedded	3.0	x	x	✓
B51	Detached	0.0	Interbedded	0.0	✓	x	x
B52	Detached	4.0	Interbedded	4.0	x	x	✓
C12	Detached	9.0	Granular	9.0	x	x	✓
C13	Semi-detached	7.0	Granular	7.0	x	x	✓

C14	Semi-detached	6.0	Granular	6.0			
C15	Detached	4.0	Granular	4.0	✗	✗	✓
C16	Semi-detached	2.0	Granular	2.0	✗	✗	✓
C17	Semi-detached	1.0	Granular	1.0			
C18	Semi-detached	0.0	Granular	0.0	✓	✗	✗
C19	Semi-detached	0.0	Granular	0.0			
C20	Detached	-1.0	Granular	0.0	✓	✗	✗
C21	Terraced	-3.0	Granular	0.0	✓	✗	✗
C22	Terraced	-4.0	Granular	0.0	✓	✗	✗
C23	Terraced	-5.0	Granular	0.0	✓	✗	✗
C24	Detached	-7.0	Granular	0.0	✓	✗	✗
C25	Detached	-8.0	Granular	0.0	✓	✗	✗
C26	Semi-detached	8.0	Granular	8.0	✗	✗	✓
C27	Semi-detached	8.0	Granular	8.0			
C28	Semi-detached	6.0	Granular	6.0	✗	✗	✓
C29	Semi-detached	6.0	Granular	6.0			
C30	Detached	4.0	Granular	4.0	✗	✗	✓
C31	Terraced	3.0	Granular	3.0	✗	✗	✓
C32	Terraced	3.0	Granular	3.0	✗	✗	✓
C33	Terraced	3.0	Granular	3.0	✗	✗	✓
C34	Detached	2.0	Granular	2.0	✗	✗	✓
C35	Semi-detached	0.0	Granular	0.0	✓	✗	✗
C36	Semi-detached	-1.0	Granular	0.0			
C37	Semi-detached	-1.0	Granular	0.0	✓	✗	✗
C38	Semi-detached	-1.0	Granular	0.0			
C39	Detached	-1.0	Granular	0.0	✓	✗	✗
C40	Terraced	-1.0	Granular	0.0	✓	✗	✗
C41	Terraced	-1.0	Granular	0.0	✓	✗	✗
C42	Terraced	-2.0	Granular	0.0	✓	✗	✗
C43	Detached	-1.0	Granular	0.0	✓	✗	✗
C44	Semi-detached	-1.0	Granular	0.0	✓	✗	✗
C45	Semi-detached	-1.0	Granular	0.0			
D016	Semi-detached	6.0	Granular	6.0	✗	✗	✓
D017	Semi-detached	6.0	Granular	6.0			
D018	Semi-detached	5.0	Granular	5.0	✗	✗	✓
D019	Semi-detached	5.0	Granular	5.0			
D020	Detached	6.0	Granular	6.0	✗	✗	✓
D021	Detached	0.0	Granular	0.0	✓	✗	✗
D022	Detached	-2.0	Granular	0.0	✓	✗	✗
D023	Detached	-3.0	Granular	0.0	✓	✗	✗
D024	Detached	-4.0	Granular	0.0	✓	✗	✗
D025	Semi-detached	-4.0	Interbedded	0.0	✓	✗	✗
D026	Semi-detached	-4.0	Interbedded	0.0			
D027	Semi-detached	-4.0	Interbedded	0.0	✓	✗	✗

D028	Semi-detached	-4.0	Interbedded	0.0			
D029	Terraced	-3.0	Interbedded	0.0	✓	x	x
D030	Terraced	-3.0	Granular	0.0	✓	x	x
D031	Terraced	-3.0	Granular	0.0	✓	x	x
D032	Terraced	-3.0	Granular	0.0	✓	x	x
D033	Terraced	-3.0	Granular	0.0	✓	x	x
D034	Terraced	-3.0	Granular	0.0	✓	x	x
D035	Detached	-3.0	Granular	0.0	✓	x	x
D036	Detached	-2.0	Granular	0.0	✓	x	x
D037	Detached	1.0	Granular	1.0	x	✓	x
B53	Semi-detached	1.0	Interbedded	1.6			
B54	Semi-detached	1.0	Interbedded	1.6	x	x	✓
B55	Semi-detached	0.0	Interbedded	1.9			
B56	Semi-detached	0.0	Interbedded	1.9	x	x	✓
B57	Detached	0.0	Interbedded	1.9	x	x	✓
B58	Semi-detached	-1.0	Granular	0.0			
B59	Semi-detached	-1.0	Granular	0.0	✓	x	x
B60	Semi-detached	-2.0	Granular	0.0			
B61	Semi-detached	-3.0	Granular	0.0	✓	x	x
B62	Semi-detached	-4.0	Granular	0.0			
B63	Semi-detached	-4.0	Granular	0.0	✓	x	x
B64	Terraced	-4.0	Granular	0.0			
B65	Terraced	-3.0	Granular	0.0	✓	x	x
B66	Terraced	-3.0	Granular	0.0	✓	x	x
B67	Detached	-1.0	Cohesive	0.0	✓	x	x
B68	Detached	0.0	Granular	0.0	✓	x	x
B69	Detached	1.0	Granular	1.0	x	✓	x
B70	Detached	1.0	Granular	1.0	x	✓	x
B71	Semi-detached	1.0	Granular	1.0			
B72	Semi-detached	1.0	Granular	1.0	x	✓	x
B73	Detached	1.0	Granular	1.0	x	✓	x
B74	Semi-detached	2.0	Granular	2.0			
B75	Semi-detached	3.0	Interbedded	3.0	x	x	✓
B76	Detached	3.0	Interbedded	3.0	x	x	✓
B77	Detached	3.0	Interbedded	3.0	x	x	✓
B78	Detached	5.0	Interbedded	5.0	x	x	✓
B79	Detached	5.0	Interbedded	5.0	x	x	✓
B80	Semi-detached	4.0	Interbedded	4.0			
B81	Semi-detached	4.0	Interbedded	4.0	x	x	✓
B82	Detached	3.0	Interbedded	3.0	x	x	✓
B83	Detached	2.0	Interbedded	2.0	x	x	✓
B84	Detached	2.0	Interbedded	2.0	x	x	✓
B85	Semi-detached	1.0	Interbedded	1.0			
B86	Semi-detached	1.0	Interbedded	1.0	x	✓	x

B87	Semi-detached	0.0	Granular	0.0	✓	x	x
B88	Semi-detached	-1.0	Granular	0.0	✓	x	x
B89	Detached	-1.0	Granular	0.0	✓	x	x
B90	Detached	-1.0	Granular	0.0	✓	x	x
B91	Detached	-1.0	Granular	0.0	✓	x	x
B92	Detached	-2.0	Granular	0.0	✓	x	x
B93	Detached	-1.0	Interbedded	0.0	✓	x	x
B94	Detached	-5.0	Interbedded	0.0	✓	x	x
B95	Terraced	-5.0	Interbedded	0.0	✓	x	x
B96	Terraced	-5.0	Interbedded	0.0	✓	x	x
B97	Terraced	-6.0	Interbedded	0.0	✓	x	x
B98	Detached	-5.0	Interbedded	0.0	✓	x	x
B99	Semi-detached	-2.0	Interbedded	0.0	✓	x	x
B100	Semi-detached	-1.0	Interbedded	0.0			
B101	Semi-detached	0.0	Granular	0.0	✓	x	x
B102	Semi-detached	0.0	Granular	0.0			
B103	Detached	0.0	Granular	0.0	✓	x	x
B104	Detached	-1.0	Granular	0.0	✓	x	x
B105	Detached	0.0	Granular	0.0	✓	x	x
C46	Semi-detached	-7.0	Interbedded	0.0	✓	x	x
C47	Semi-detached	-7.0	Interbedded	0.0			
C48	Semi-detached	-6.0	Interbedded	0.0	✓	x	x
C49	Semi-detached	-5.0	Interbedded	0.0			
C50	Detached	-4.0	Interbedded	0.0	✓	x	x
C51	Detached	-4.0	Interbedded	0.0	✓	x	x
C52	Terraced	-5.0	Interbedded	0.0	✓	x	x
C53	Terraced	-4.0	Interbedded	0.0	✓	x	x
C54	Terraced	-4.0	Interbedded	0.0	✓	x	x
C55	Detached	-2.0	Interbedded	0.0	✓	x	x
C56	Terraced	-1.0	Interbedded	0.0	✓	x	x
C57	Terraced	0.0	Interbedded	0.0	✓	x	x
C58	Terraced	0.0	Cohesive	0.0	✓	x	x
C59	Semi-detached	0.0	Cohesive	0.0	✓	x	x
C60	Semi-detached	0.0	Cohesive	0.0	✓	x	x
C61	Detached	1.0	Cohesive	1.0	x	✓	x
C62	Detached	2.0	Cohesive	2.0	x	x	✓
B106	Detached	1.0	Interbedded	1.0	x	✓	x
B107	Semi-detached	2.0	Interbedded	2.0	x	x	✓
B108	Semi-detached	2.0	Interbedded	2.0	x	x	✓
B109	Detached	2.0	Interbedded	2.0	x	x	✓
B110	Semi-detached	3.0	Interbedded	3.0	x	x	✓
B111	Semi-detached	2.0	Interbedded	2.0	x	x	✓
B112	Detached	2.0	Interbedded	2.0	x	x	✓
B113	Semi-detached	1.0	Granular	1.0	x	✓	x

B114	Semi-detached	0.0	Granular	0.0	✓	×	×
B115	Semi-detached	0.0	Granular	0.0	✓	×	×
B116	Semi-detached	0.0	Granular	0.0	✓	×	×
B117	Detached	0.0	Granular	0.0	✓	×	×
B118	Terraced	-1.0	Granular	0.0	✓	×	×
B119	Terraced	-1.0	Granular	0.0	✓	×	×
B120	Terraced	-2.0	Cohesive	0.0	✓	×	×
B121	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
B122	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
B123	Semi-detached	-4.0	Cohesive	0.0	✓	×	×
B124	Semi-detached	-4.0	Cohesive	0.0	✓	×	×
B125	Detached	-3.0	Cohesive	0.0	✓	×	×
B126	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
B127	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
B128	Detached	-2.0	Cohesive	0.0	✓	×	×
B129	Detached	0.0	Cohesive	0.0	✓	×	×
B130	Semi-detached	1.0	Cohesive	1.0	×	✓	×
B131	Semi-detached	1.0	Cohesive	1.0	×	✓	×
B132	Semi-detached	1.0	Granular	2.3	×	×	✓
B133	Semi-detached	1.0	Granular	2.3	×	×	✓
B134	Semi-detached	1.0	Granular	2.3	×	×	✓
B135	Semi-detached	2.0	Granular	3.3	×	×	✓
B136	Semi-detached	2.0	Granular	3.3	×	×	✓
B137	Semi-detached	3.0	Granular	4.3	×	×	✓
B138	Semi-detached	3.0	Granular	4.3	×	×	✓
B139	Semi-detached	3.0	Interbedded	4.3	×	×	✓
B140	Semi-detached	3.0	Interbedded	4.3	×	×	✓
B141	Semi-detached	3.0	Interbedded	4.3	×	×	✓
B142	Semi-detached	3.0	Interbedded	4.3	×	×	✓
B143	Semi-detached	2.0	Interbedded	3.3	×	×	✓
B144	Detached	0.0	Interbedded	1.3	×	✓	×
B145	Detached	-1.0	Interbedded	0.0	✓	×	×
C63	Detached	-4.0	Granular	0.0	✓	×	×
C64	Detached	-3.0	Granular	0.0	✓	×	×
C65	Detached	-2.0	Granular	0.0	✓	×	×
C66	Semi-detached	-1.0	Granular	0.0	✓	×	×
C67	Semi-detached	-2.0	Granular	0.0	✓	×	×
C68	Detached	-3.0	Granular	0.0	✓	×	×
C69	Semi-detached	-3.0	Granular	0.0	✓	×	×
C70	Semi-detached	-4.0	Granular	0.0	✓	×	×
C71	Detached	-3.0	Granular	0.0	✓	×	×
C72	Semi-detached	-2.0	Granular	0.0	✓	×	×
C73	Semi-detached	-1.0	Granular	0.0	✓	×	×
C74	Detached	1.0	Granular	1.0	×	✓	×

C75	Semi-detached	2.0	Granular	2.0	×	×	✓
C76	Semi-detached	3.0	Granular	3.0	×	×	✓
C77	Semi-detached	3.0	Granular	3.0	×	×	✓
C78	Semi-detached	3.0	Granular	3.0	×	×	✓
C79	Semi-detached	3.0	Interbedded	3.0	×	×	✓
C80	Semi-detached	4.0	Interbedded	4.0	×	×	✓
D038	Detached	-1.0	Granular	0.0	✓	×	×
D039	Detached	-1.0	Granular	0.0	✓	×	×
D040	Detached	-4.0	Granular	0.0	✓	×	×
D041	Semi-detached	-3.0	Granular	0.0	✓	×	×
D042	Semi-detached	-3.0	Granular	0.0	✓	×	×
D043	Detached	-1.0	Granular	0.0	✓	×	×
D044	Detached	0.0	Granular	0.0	✓	×	×
D045	Semi-detached	0.0	Granular	0.0	✓	×	×
D046	Semi-detached	0.0	Granular	0.0	✓	×	×
D047	Detached	1.0	Granular	1.0	×	✓	×
D048	Semi-detached	1.0	Granular	1.0	×	✓	×
D049	Semi-detached	1.0	Granular	1.0	×	✓	×
D050	Terraced	2.0	Granular	2.0	×	×	✓
D051	Terraced	3.0	Granular	3.0	×	×	✓
D052	Terraced	3.0	Granular	3.0	×	×	✓
D053	Detached	2.0	Granular	2.0	×	×	✓
D054	Detached	4.0	Granular	4.0	×	×	✓
D055	Detached	0.0	Granular	0.0	✓	×	×
D056	Detached	-1.0	Granular	0.0	✓	×	×
D057	Detached	-1.0	Granular	0.0	✓	×	×
D058	Detached	-2.0	Granular	0.0	✓	×	×
D059	Detached	-3.0	Granular	0.0	✓	×	×
D060	Detached	-3.0	Granular	0.0	✓	×	×
D061	Detached	-2.0	Granular	0.0	✓	×	×
D062	Detached	-4.0	Granular	0.0	✓	×	×
D063	Detached	-3.0	Interbedded	0.0	✓	×	×
D064	Detached	-3.0	Granular	0.0	✓	×	×
D065	Detached	-2.0	Granular	0.0	✓	×	×
D066	Detached	-2.0	Granular	0.0	✓	×	×
D067	Detached	-2.0	Granular	0.0	✓	×	×
D068	Detached	-1.0	Granular	0.0	✓	×	×
D069	Detached	2.0	Granular	2.0	×	×	✓
D070	Detached	4.0	Granular	4.0	×	×	✓
D071	Detached	3.0	Granular	3.0	×	×	✓
D072	Detached	3.0	Granular	3.0	×	×	✓
D073	Detached	0.0	Granular	0.0	✓	×	×
D074	Detached	-1.0	Granular	0.0	✓	×	×
D075	Detached	-1.0	Granular	0.0	✓	×	×

D076	Detached	-1.0	Interbedded	0.0	✓	x	x
D077	Detached	-1.0	Interbedded	0.0	✓	x	x
D078	Detached	-1.0	Interbedded	0.0	✓	x	x
D079	Detached	-1.0	Interbedded	0.0	✓	x	x
D080	Detached	0.0	Interbedded	0.0	✓	x	x
D081	Detached	0.0	Interbedded	0.0	✓	x	x
D082	Detached	0.0	Interbedded	0.0	✓	x	x
D083	Detached	0.0	Interbedded	0.0	✓	x	x
D084	Detached	1.0	Granular	1.0	x	✓	x
D085	Detached	1.0	Interbedded	1.0	x	✓	x
D086	Detached	0.0	Interbedded	0.0	✓	x	x
D087	Detached	-2.0	Interbedded	0.0	✓	x	x
D088	Semi-detached	-2.0	Interbedded	0.0	✓	x	x
D089	Semi-detached	-2.0	Granular	0.0	✓	x	x
D090	Detached	-2.0	Granular	0.0	✓	x	x
D091	Semi-detached	-2.0	Granular	0.0	✓	x	x
D092	Semi-detached	-1.0	Granular	0.0	✓	x	x
D093	Detached	0.0	Granular	0.0	✓	x	x
D094	Detached	0.0	Granular	0.0	✓	x	x
D095	Detached	1.0	Granular	1.0	x	✓	x
D096	Terraced	-1.0	Cohesive	0.0	✓	x	x
D097	Terraced	-1.0	Cohesive	0.0	✓	x	x
D098	Terraced	-1.0	Cohesive	0.0	✓	x	x
D099	Terraced	-1.0	Cohesive	0.0	✓	x	x
D100	Semi-detached	-1.0	Interbedded	0.0	✓	x	x
D101	Semi-detached	-1.0	Interbedded	0.0	✓	x	x
D102	Detached	-2.0	Interbedded	0.0	✓	x	x
D103	Semi-detached	-1.0	Interbedded	0.0	✓	x	x
D104	Semi-detached	-1.0	Interbedded	0.0	✓	x	x
D105	Semi-detached	-1.0	Interbedded	0.0	✓	x	x
D106	Semi-detached	-1.0	Cohesive	0.0	✓	x	x
D107	Terraced	-2.0	Cohesive	0.0	✓	x	x
D108	Terraced	-1.0	Cohesive	0.0	✓	x	x
D109	Terraced	-1.0	Cohesive	0.0	✓	x	x
D110	Terraced	-1.0	Cohesive	0.0	✓	x	x
D111	Terraced	-1.0	Cohesive	0.0	✓	x	x
D112	Terraced	-1.0	Cohesive	0.0	✓	x	x
D113	Semi-detached	-1.0	Cohesive	0.0	✓	x	x
D114	Semi-detached	-1.0	Cohesive	0.0	✓	x	x
D115	Detached	0.0	Cohesive	1.9	x	x	✓
D116	Terraced	-1.0	Cohesive	0.0	✓	x	x
D117	Terraced	-2.0	Cohesive	0.0	✓	x	x
D118	Terraced	-2.0	Cohesive	0.0	✓	x	x
D119	Semi-detached	-2.0	Cohesive	0.0	✓	x	x

D120	Semi-detached	-2.0	Cohesive	0.0	✓	×	×
D121	Detached	-1.0	Interbedded	0.0	✓	×	×
D122	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
D123	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
D124	Detached	-3.0	Cohesive	0.0	✓	×	×
D125	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
D126	Semi-detached	-3.0	Cohesive	0.0	✓	×	×
D127	Semi-detached	-2.0	Cohesive	0.0	✓	×	×
D128	Semi-detached	-2.0	Granular	0.0	✓	×	×
D129	Semi-detached	-1.0	Interbedded	0.0	✓	×	×
D130	Semi-detached	-1.0	Interbedded	0.0	✓	×	×
D131	Semi-detached	-1.0	Granular	0.0	✓	×	×
D132	Semi-detached	-1.0	Granular	0.0	✓	×	×
D133	Detached	-1.0	Granular	0.0	✓	×	×
D134	Terraced	-1.0	Granular	0.0	✓	×	×
D135	Terraced	-2.0	Granular	0.0	✓	×	×
D136	Terraced	-2.0	Granular	0.0	✓	×	×
D137	Detached	-2.0	Granular	0.0	✓	×	×
D138	Semi-detached	-2.0	Granular	0.0	✓	×	×
D139	Semi-detached	-2.0	Granular	0.0	✓	×	×
D140	Detached	-1.0	Granular	0.0	✓	×	×
D141	Detached	-1.0	Granular	0.0	✓	×	×
D142	Detached	3.0	Interbedded	3.0	×	×	✓
D143	Detached	1.0	Interbedded	1.0	×	✓	×
C81	Detached	2.0	Interbedded	2.0	×	×	✓
C82	Semi-detached	1.0	Interbedded	1.0	×	✓	×
C83	Semi-detached	1.0	Interbedded	1.0	×	✓	×
C84	Semi-detached	1.0	Interbedded	1.0	×	✓	×
C85	Semi-detached	1.0	Granular	1.0	×	✓	×
C86	Detached	0.0	Granular	0.0	✓	×	×
C87	Terraced	0.0	Granular	0.0	✓	×	×
C88	Terraced	1.0	Granular	1.0	×	✓	×
C89	Terraced	1.0	Granular	1.0	×	✓	×
C90	Detached	1.0	Granular	2.9	×	×	✓
C91	Semi-detached	0.0	Granular	1.9	×	✓	×
C92	Semi-detached	0.0	Granular	1.9	×	✓	×
C93	Detached	0.0	Granular	1.9	×	✓	×
C94	Semi-detached	-1.0	Granular	0.0	✓	×	×
C95	Semi-detached	-1.0	Granular	0.0	✓	×	×
C96	Terraced	-1.0	Granular	0.0	✓	×	×
C97	Terraced	-1.0	Interbedded	0.0	✓	×	×
C98	Terraced	-1.0	Interbedded	0.0	✓	×	×
C99	Detached	-2.0	Interbedded	0.0	✓	×	×
C100	Semi-detached	-2.0	Cohesive	0.0	✓	×	×

C101	Semi-detached	-2.0	Cohesive	0.0	✓	×	×
C102	Semi-detached	-2.0	Cohesive	0.0	✓	×	×
C103	Semi-detached	-2.0	Cohesive	0.0	✓	×	×
C104	Detached	-2.0	Cohesive	0.0	✓	×	×
C105	Detached	-3.0	Cohesive	0.0	✓	×	×
C106	Detached	-3.0	Cohesive	0.0	✓	×	×
C107	Detached	-3.0	Cohesive	0.0	✓	×	×
C108	Detached	-4.0	Cohesive	0.0	✓	×	×
C109	Terraced	-4.0	Cohesive	0.0	✓	×	×
C110	Terraced	-4.0	Cohesive	0.0	✓	×	×
C111	Terraced	-4.0	Cohesive	0.0	✓	×	×
C112	Terraced	-4.0	Cohesive	0.0	✓	×	×
C113	Terraced	-4.0	Interbedded	0.0	✓	×	×
C114	Terraced	-3.0	Interbedded	0.0	✓	×	×
C115	Terraced	-3.0	Granular	0.0	✓	×	×
C116	Terraced	-3.0	Granular	0.0	✓	×	×
C117	Terraced	-3.0	Granular	0.0	✓	×	×
C118	Terraced	-2.0	Granular	0.0	✓	×	×
C119	Terraced	-2.0	Granular	0.0	✓	×	×
C120	Terraced	-2.0	Granular	0.0	✓	×	×
C121	Semi-detached	-2.0	Granular	0.0	✓	×	×
C122	Semi-detached	-2.0	Granular	0.0	✓	×	×
C123	Semi-detached	-1.0	Granular	0.0	✓	×	×
C124	Semi-detached	-1.0	Granular	0.0	✓	×	×
C125	Terraced	-1.0	Interbedded	0.0	✓	×	×
C126	Terraced	-1.0	Interbedded	0.0	✓	×	×
C127	Terraced	0.0	Interbedded	0.0	✓	×	×
C128	Detached	1.0	Interbedded	1.0	×	✓	×
C129	Detached	1.0	Interbedded	1.0	×	✓	×
C130	Detached	1.0	Interbedded	1.0	×	✓	×
C131	Detached	1.0	Interbedded	1.0	×	✓	×
B146	Detached	1.0	Interbedded	1.0	×	✓	×
B147	Detached	0.0	Interbedded	0.0	✓	×	×
B148	Semi-detached	1.0	Interbedded	1.0	×	✓	×
B149	Semi-detached	1.0	Interbedded	1.0	×	✓	×
B150	Semi-detached	0.0	Interbedded	0.0	✓	×	×
B151	Semi-detached	0.0	Interbedded	0.0	✓	×	×
B152	Detached	1.0	Granular	1.0	×	✓	×
B153	Semi-detached	1.0	Granular	1.0	×	✓	×
B154	Semi-detached	1.0	Granular	1.0	×	✓	×
B155	Semi-detached	-1.0	Granular	0.0	✓	×	×
B156	Semi-detached	0.0	Granular	0.0	✓	×	×
B157	Semi-detached	-1.0	Granular	0.0	✓	×	×
B158	Semi-detached	-1.0	Granular	0.0	✓	×	×

B159	Semi-detached	-1.0	Granular	0.0	✓	×	×
B160	Semi-detached	-1.0	Granular	0.0	✓	×	×
B161	Semi-detached	-1.0	Interbedded	0.0	✓	×	×
B162	Semi-detached	-1.0	Interbedded	0.0	✓	×	×
B163	Semi-detached	-1.0	Interbedded	0.0	✓	×	×
B164	Semi-detached	-1.0	Cohesive	0.0	✓	×	×
B165	Semi-detached	-1.0	Cohesive	0.0	✓	×	×
B166	Semi-detached	-1.0	Cohesive	0.0	✓	×	×
B167	Detached	-1.0	Cohesive	0.0	✓	×	×
B168	Detached	-2.0	Cohesive	0.0	✓	×	×
B169	Detached	-1.0	Cohesive	0.0	✓	×	×
B170	Detached	-3.0	Cohesive	0.0	✓	×	×
B171	Detached	-2.0	Cohesive	0.0	✓	×	×

Notes:

* Shallow strip foundations with a width of up to 1.2m and a minimum depth of 0.9m bgl are deemed feasible. An allowable bearing capacity of 100kPa is anticipated from the underlying natural soils. Foundations should be taken through any Made Ground, and a minimum of 0.3m into the natural soils.

** Shallow foundation extended through the Made Ground and into a minimum of 0.3m of natural soils are deemed feasible. Strip foundations with a width of up to 1.2m and pad foundations with a width of up to 1.5m will achieve an allowable bearing capacity of 100kPa.

*** Piled foundations will be required due to thickness of the proposed earthworks. Piled foundations will need to be taken through the Made Ground/fill and into the natural undisturbed soils. Consideration should be given to production and implementation of an earthworks specification. Engineering and validation of the proposed earthworks would allow for the use of raft foundations, as well as reducing the risk associated with differential settlement of proposed infrastructure and retaining walls.

Table 6-H: Plot-specific anticipated foundation types

6.15 Residential Ground Floor Construction

- 6.15.1 Where spread foundations are adopted, ground bearing floor slabs can be adopted where they are remote from trees and where Made Ground/Alluvium/Topsoil deposits are fully removed within the footprint of the building. Following completion of excavations to formation levels it is recommended that the formation is proof rolled to identify any soft areas, which if encountered should be excavated and replaced with suitably compacted engineered fill. It is further recommended that a layer of durable, well graded compacted granular material be placed prior to construction of the floor slabs.
- 6.15.2 If raft type foundations are adopted, such a foundation solution will provide adequate ground floor support.
- 6.15.3 In areas close to existing major vegetation at the site, or if piled foundations are adopted in areas of significant fill, then it is recommended that suspended ground floors are adopted with a sub floor void determined in accordance with NHBC Standards.

6.16 Slope Stability

- 6.16.1 A Preliminary Slope Stability Assessment was undertaken in March 2023 (Report ref: STV5936-R01-Rev_A), which was based on historical ground investigation information. The analyses were based around a nominal slope with the following key parameters:
- 1V:3H slope angle
 - Maximum height of slope = 3m
 - Loading at crest = nominal 10kPa uniformly distributed load representing construction traffic. Nominally set back 1m from edge of crest.
 - Groundwater nominally 0.5m below surface
- 6.16.2 That assessment also included sensitivity analyses where key variables were varied to determine the impact on the Factor of Safety (Fos) of the slope.
- 6.16.3 A supplementary ground investigation has since been undertaken and is summarised within this report. These additional works and associated laboratory testing have allowed for the refinement of the ground model and geotechnical parameters. The parameters presented in Section 6.9 have been adopted for the in situ material.
- 6.16.4 The proposed scheme involves considerable earthworks which are discussed further in Sections 6.20 to 6.22. As part of those earthworks, slopes will be created in the in situ material and also the placed material. There will be a degree of material control for the placed slopes. In contrast the cut slopes will be in virgin material, with no control of the material composition.
- 6.16.5 The in situ material comprises Hummocky Glacial Deposits. Whilst the material is primarily granular in composition (approximately 70%) it also contains a notable proportion of fine grained material. The lateral and vertical distribution of the fine grained material is not consistent across the site and therefore it is not possible to zone the site accordingly. On this basis, the long term stability of slopes cut into the in situ material has been assessed based on the fine grained material being present and therefore the controlling element.
- 6.16.6 The ground investigation and subsequent monitoring has indicated that groundwater is typically at least 1m below the surface. Accordingly, a slope gradient of 1V:3H is considered appropriate for slopes cut into in situ soils, and will provide a global FoS > 1.3.
- 6.16.7 In certain locations the proposed finished level will be below the monitored groundwater level. Such a scenario will lead to failure of the slope and must be avoided. Deep drainage could be installed upslope of the problem locations to intercept water before it reaches the surface. This option also has the added benefit of promoting stability during the temporary works and is therefore recommended. Alternatively, proposed levels could be adjusted to ensure cut levels remain above groundwater levels.

- 6.16.8 It is assumed that during the excavation works the material will be segregated based on material composition. On this basis three material streams are anticipated: Topsoil, fine grained Hummocky Glacial Deposits and granular Hummocky Glacial Deposits. It is recommended that slopes constructed as part of the earthworks are formed using the Granular Hummocky Glacial Deposits as this will allow a steeper slope angle to be adopted for the works due to better material properties. The 'core' of the earthworks can still be constructed with the fine-grained Hummocky Glacial Deposits, on the proviso that it is suitably compacted. It is assumed that the granular element will comprise the upper 2.0m of material.
- 6.16.9 This updated analysis is presented below ($FoS = 1.498$), based on a friction angle of 31° within the re-engineered Granular Hummocky Glacial Deposits, and a slope of 1V:2.5H. It is further assumed that drainage will be installed as part of the works such that groundwater does not rise above 1m BGL.

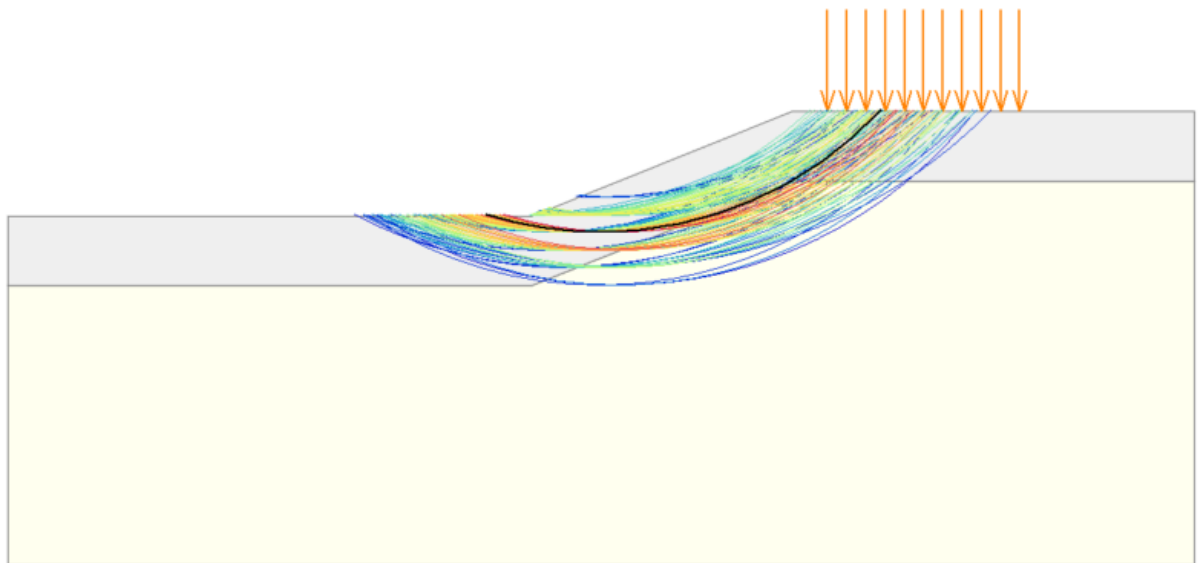
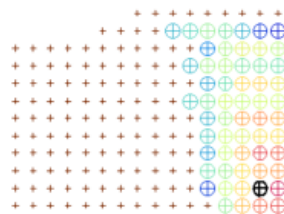


Figure 6-A: slope stability analysis illustrating re-engineered upper granular layer

6.17 Aggressiveness of the Ground to Buried Concrete

- 6.17.1 The aggressiveness of the ground with respect to buried concrete has been assessed in accordance with Building Research Establishment Special Digest 1: Concrete in Aggressive Ground Third Edition (2005).
- 6.17.2 The site is interpreted to be a greenfield site where pyrite is unlikely to be present.
- 6.17.3 Laboratory testing has been undertaken on soil samples obtained from the investigation works.
- 6.17.4 The classification of the strata is tabulated below:

Stratum	Disturbed / Undisturbed	Design sulphate class	Aggressive chemical environment for concrete class
Made Ground	Disturbed	DS-1	AC-1s
Hummocky Glacial Deposits	Disturbed	DS-1	AC-1s
	Undisturbed	DS-1	AC-1s

Table 6-1: Summary of the aggressiveness of the ground to buried concrete

6.18 Drainage

- 6.18.1 The Hummocky Glacial Deposits were observed as variable fine granular and cohesive deposits. Large scale earthworks are proposed, and it is not recommend to dispose of stormwater in close proximity to slopes and in areas of fill, which could promote collapse settlement and slope instability.
- 6.18.2 It is noted based on previous investigations undertaken by Smith Grant in 2017, permeability testing was undertaken within groundwater monitoring wells installed in boreholes BHD, BHG, BHH, BHI, BHK, BHL, BHM and BHN. Response zones were largely installed within variable strata, clays and silts with sand lenses, however response zones in boreholes BHG, BHH and BHL were largely within sands.
- 6.18.3 Permeability was measured between 1.4×10^{-6} m/s to 1.4×10^{-7} m/s, with results suggesting relatively low permeability site wide, with the sand deposits exhibiting no greater permeability than the clays/silts.
- 6.18.4 Qualitative and quantitative assessments indicate that natural Hummocky Glacial Deposits are unlikely to exhibit sufficient permeability to allow the use of SUDS at the site. If such systems are considered, it is recommended that in situ testing within this stratum is undertaken during completion of the earthworks phase of the development to facilitate a quantitative assessment. The in-situ testing should be undertaken in accordance with in BRE 365: Soakaway Design (2016).

6.19 Pavement Foundation

- 6.19.1 As part of the development, significant cut and fill is proposed to facilitate development of the site. Accordingly, ground conditions at formation level will be variable, and the degree of compaction achieved to fill will dictate overall CBR values in such areas. Laboratory CBR testing has been undertaken on remoulded samples and are therefore considered to be representative of the material after earthworks operations where filling is proposed.
- 6.19.2 For coarse-grained materials 7No. of the 12No. samples analysed recorded a remoulded CBR value of <0.5% and 2No. having a CBR of >50%. As such it is recommended that coarse-grained soils are suitably conditioned under pavement formation to achieve a uniform CBR value.
- 6.19.3 For fine-grained materials 4No. of the 10No. samples analysed recorded a remoulded CBR value of <1.0%, with a maximum of 4.7% and an average CBR of 2.3% was recorded across all 10No. samples. As such it is recommended that fine-grained soils are suitably conditioned under pavement formation to achieve a uniform CBR value.
- 6.19.4 It is noted based on previous investigations undertaken by Smith Grant in 2017, 8 No. remoulded CBR tests were completed on Hummocky Glacial Deposits from across the site. Silt and Sands generally indicated CBR values of <1.0%, with a clay sample measured at just over 1.0%.

- 6.19.5 It is recommended that in situ testing of the soils below proposed pavement formation be undertaken following completion of filling operations to confirm California Bearing Ratio (CBR) value prior to road construction. A CBR value of 2.5% could be adopted at this stage as a preliminary design value for areas to be filled, assuming soils would be conditioned to some extent prior to placement.
- 6.19.6 Where natural undisturbed soils are to be left at surface, subgrade is anticipated to comprise a mix of granular and clay based soils. The clay based soils will typically govern the overall in situ CBR value. On this basis, we recommend utilising a similar value of 2.5% for preliminary design.
- 6.19.7 It is recommended that the design values are validated with in situ testing immediately prior to construction. Furthermore, it is recommended that the formation level is trimmed and rolled following the requirements outlined in the Specification for Highway Works Series 600.
- 6.19.8 The Hummocky Glacial deposits are considered frost susceptible and this may override the CBR criteria for pavement foundation design purposes.
- 6.19.9 The silty nature of the Hummocky Glacial deposits will render them moisture susceptible with small increases in moisture content giving rise to a rapid loss of support to construction plant. It is therefore recommended that the sub-base is laid as soon as practicable following establishment of formation.

6.20 Earthworks Classification

- 6.20.1 The project is in the preliminary stages of planning. Accordingly, the exact requirements and anticipated volume of materials generated during proposed earthworks are yet to be finalised. As such, this specification is considered preliminary and may be subject to revision if development proposals change.
- 6.20.2 It is understood that the proposed development will comprise construction of 445 residential units across the extent of the site. According to the preliminary cut and fill drawing presented in Appendix A, it is estimated that circa 323,000m³ of soil will be cut from site, and 223,000m³ will be required as fill; generating an excess of approximately 100,000m³. This excess will be further increased by arisings generated from foundation/service/ highway excavations. It is anticipated that approximately 112,439m³ of Topsoil is currently on site; although it is understood that some of this material will be exported from site during development.
- 6.20.3 The preliminary cut and fill drawing, presented in Appendix A (Drawing 02), outlines the preliminary cut and fill requirements for the development. Based on this, it is anticipated that soils from proposed 'cut' locations will comprise predominantly interdigitated fine and coarse grained material within the naturally deposited Hummocky Glacial Deposits. This excludes Topsoil material. Localised areas of Made Ground were also encountered in the southeast, northeast and west of the site, which is consistent with previous ground investigations.
- 6.20.4 Earthworks classification testing, in accordance with Table 6/1 of the Specification for Highway Works Series 600, has been undertaken on samples obtained as part of the ground investigation. Accordingly, the following principal soils are anticipated across the site:
- Class 1B: Uniformly Graded Granular, which corresponds to the coarse grained Hummocky Glacial Deposits: Medium dense to dense brown to orangish brown slightly gravelly silty fine to medium sand to silty fine sand.

- Class 2A: Wet Cohesive, which corresponds to the fine grained Hummocky Glacial Deposits: Firm to stuff brown to light brown sandy silt to slightly gravelly slightly sandy clay.

- 6.20.5 In addition to the above principal soils, Made Ground is also anticipated, comprising sandy gravelly clay with brick, concrete, coal with timber and ceramic fragments to silty sandy cobbly gravel of clinker, ceramic, glass, metal and brick fragments.
- 6.20.6 Alluvium is present at the base of the valleys extending through the site. In these locations the proposed fill heights are considerable. The Alluvium typically comprised soft, dark grey sandy gravelly Silt. Due to the soft and compressible nature of the deposit the material will need to be excavated and replaced with suitably compacted engineered fill prior to the placing of general fill. The excavated material is anticipated to be suitable for re-use as a Class 4 Landscape Fill.

6.21 Suitability of Site Won Soils for Reuse

- 6.21.1 Laboratory testing was undertaken on samples obtained as part of the ground investigation. The testing was focused on determining acceptable limits such that in situ material could be reused on site.
- 6.21.2 Compaction testing was undertaken on 12 samples of the Class 2A material to determine the maximum dry density and optimum moisture content. An upper and lower acceptable moisture content corresponding to 95% maximum dry density and subject to a maximum 10% air voids was then calculated for each sample.
- 6.21.3 Analysis of the individual results from the 12 tests indicate that 5 samples are within acceptable limits and a further 4 are within 1% of the upper moisture content limit. However, when comparing the data as a combined dataset alongside an additional 15 moisture content test results, the results are consistent with the above deduction that the material is wet of optimum.
- 6.21.4 The results are presented graphically in the box and whisker plot below. The “box” corresponds to the middle 50% of the results and the ends of the “whiskers” relate to the highest and lowest values. Wider boxes and longer whiskers are indicative of a greater spread in the data.
- 6.21.5 The results indicate that the in situ moisture content at time of testing (orange dataset) is broadly coincident with the maximum acceptable moisture content (green dataset) which indicates that the material is wet of optimum.

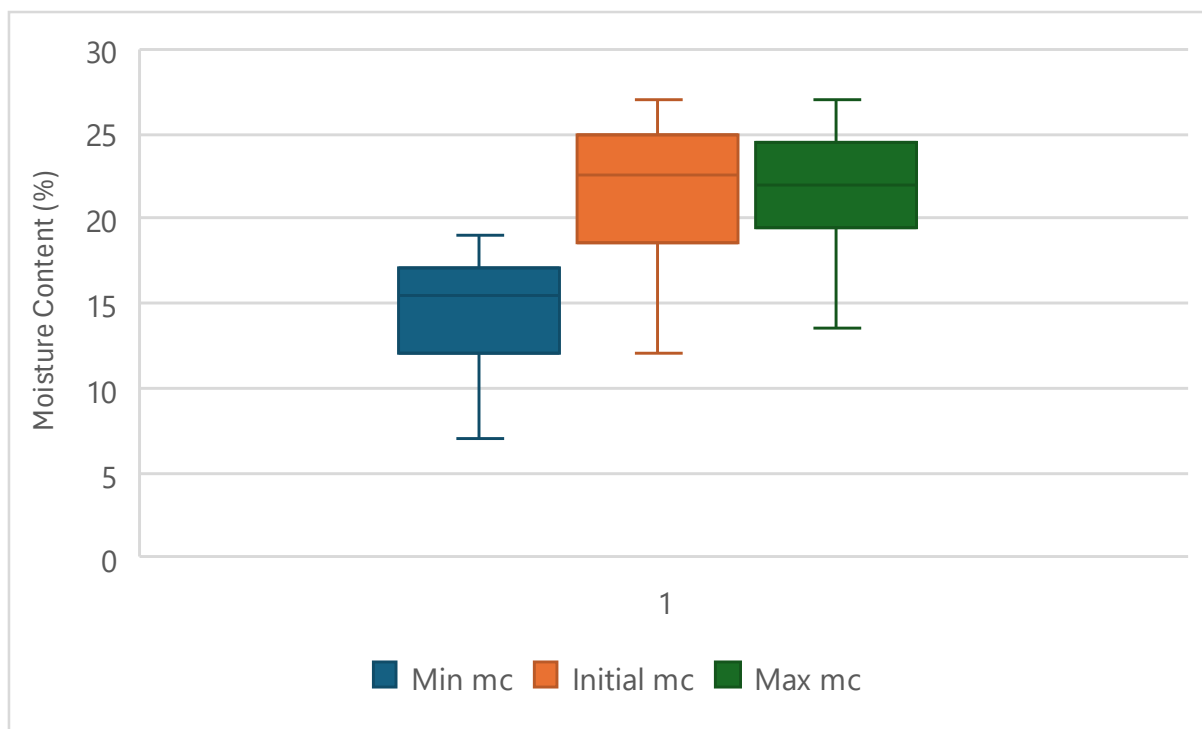


Figure 6-B: Box and whisker plot showing acceptable moisture content limits for Class 2A material

6.21.6 Compaction testing was also undertaken on 10 samples of the Class 1B material and the same process followed as described above.

6.21.7 Individually, 6 of the 10 results were within acceptable limits with the remaining 4 all within 1% of the upper moisture content limit. On this basis the soils are marginally wet of optimum. The results are also presented graphically as a box and whisker plot below.

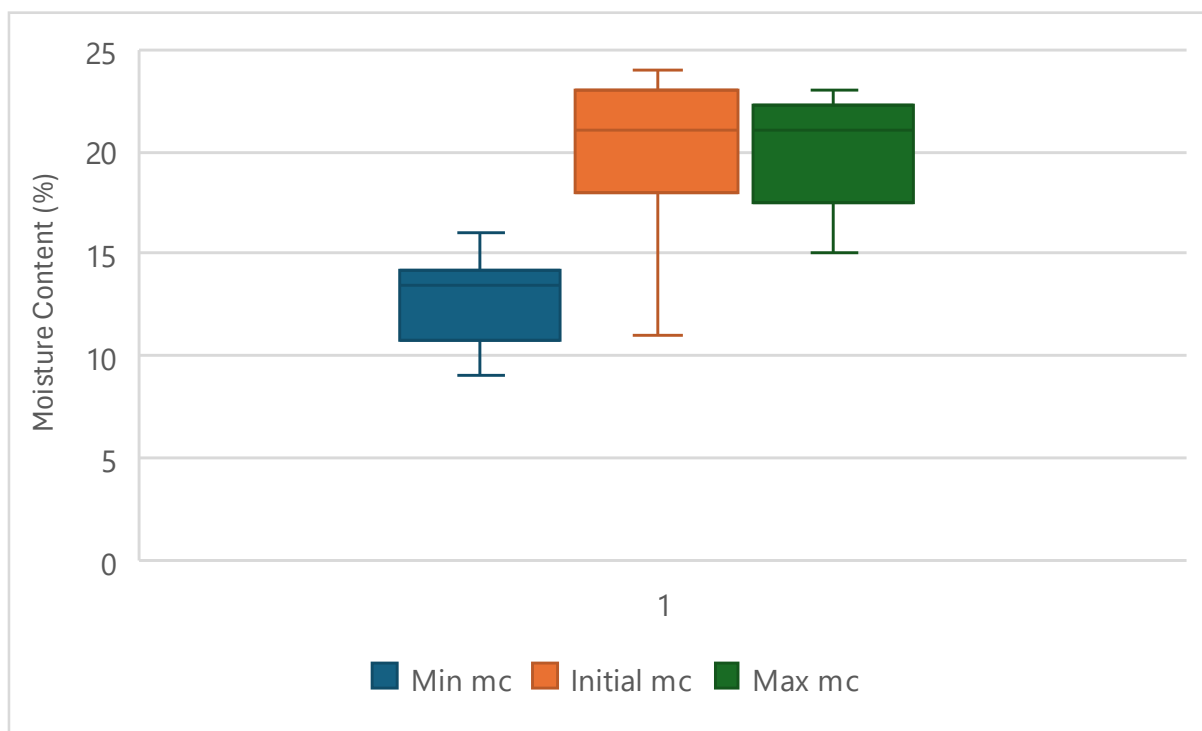


Figure 6-C: Box and whisker plot showing acceptable moisture content limits for Class 1B material

6.21.8 Both soil types are wet of optimum. However, it is anticipated that with minor conditioning (drying out) the significant proportion of the material will be suitable for re-use.

6.22 Earthworks Validation

6.22.1 The following Table presents the acceptable limits for the materials encountered on site and anticipated to be re-used as part of the works.

Class	Material Description	Property	Defined and tested in accordance with	Acceptable limits within	
				lower	upper
1B	Uniformly Graded Granular Material	i) Grading	BS 1377: part 2	Tab 6/2	Tab 6/2
		ii) Uniformity Coefficient	See Tab 6/1 Note 5	-	10
		iii) Maximum density (<i>soils placed underneath floor slabs, foundations or roads</i>)	BS 1377: part 4	95%MDD	-
2A	Wet cohesive material	i) Grading	BS1377: part 2	Tab 6/2	Tab 6/2
		ii) Plastic Limit (PL)	BS1377: part 2	-	-
		iii) Moisture content	BS1377: part 2	PL - 4%	PL + 2%
		iv) MCV	Clause 632	8	14
		v) Undrained shear strength	Clause 633	50kPa	-
		vi) Maximum density (<i>soils placed underneath floor slabs, foundations or roads</i>)	BS1377: part 4	95% MDD	-

Table 6-J: Earthworks Acceptability Criteria

6.22.2 Earthwork materials which do not conform to the criteria described in Table 6-J shall be deemed unacceptable for reuse, unless advised otherwise by the designer.

6.22.3 The Contractor shall undertake testing during the works to classify soils prior to placement and confirm that soils adhere to Class 1B or 2A as outlined above. The Contractor shall also undertake end product compaction and strength testing. The frequency of testing is stipulated in Table 6-K below.

6.22.4 The testing rates have been based on the following volumes of material likely to be reused onsite:

- 223,000m³ of material is currently required for use as fill onsite.
- 323,000m³ will be generated from reduced level dig (cut).
- Assumed that 12,500m³ of Topsoil will be reused onsite (of 112,439m³).

6.22.5 Based on the testing undertaken to date, this material is likely to consist of approximately 70% coarse-grained soils and 30% fine-grained soils. Accordingly, the following testing frequencies are recommended:

Criteria	Frequency	Number of anticipated lab/in-situ tests in each soil type	
		Class 1B (coarse)	Class 2A (fine)
Compaction relationship	Approximately 1 per 2500m ³ of material. Testing to be completed in accordance with sub clause 11 to 15 to clause 612. Additional testing (agreed with the	59	26

	overseeing Engineer) may be required for soils of varying composition.		
Plasticity (fine-grained soils)	Minimum of 1 per 2000m ³	N/A	32
Grading and Sedimentation (Including uniformity coefficient for sand)	Minimum of 1 per 2000m ³	74 of each	32 of each
Moisture Content	Minimum of 1 per 1000m ³	148	64
MCV	Minimum of 1 per 2000m ³	N/A	32
End specification compaction testing to demonstrate compliance	Minimum of 1 test every 200m ² spatially and vertically distributed across the site. Nuclear density testing and / or sand replacement techniques are permitted.	Site is 281,097m ² with ~178 No. plots constructed on fill (c.40% of the site). With an average fill depth of 4.0m and lift heights of 300mm, approx. 3,936 tests would be required.	

Table 6-K: Earthworks testing frequency

6.22.6 It should be noted that the above frequency may be increased in the event of notable non-compliances and possibly reduced if consistent, compliant results are achieved.

6.23 Constructability

- 6.23.1 Under most standard contracts it is the responsibility of the Contractor to design, construct and maintain temporary works. Accordingly, the following discussion is provided for information only.
- 6.23.2 The groundwater table will be encountered at shallow depth, particularly in the south and southeast of the site where groundwater levels were higher, or within the area of the highest site elevation (existing central plateau) where deepest cut is proposed, which may require some localised drainage to control (unless levels are adjusted to avoid groundwater).
- 6.23.3 Perched groundwater in shallow confined granular layers may be present (identified very locally to date). Dewatering may be required in shallow excavations regardless of location of site.
- 6.23.4 Excavation sides are anticipated to be stable in the short term. However, some overbreak of more granular deposits may occur.
- 6.23.5 Extraction of the Hummocky Glacial Deposits (and localised Made Ground) is anticipated to be viable using conventional excavators with shovels, backhoes and grabs.
- 6.23.6 Other items to consider in constructability:
- Spatial constraints
 - Sequencing of earthworks and construction

7 Chemical Assessment

7.1 Objectives

- 7.1.1 Detailed risk assessment has previously been undertaken by Smith Grant, where a low risk was determined to identified receptors.
- 7.1.2 The objective of this chemical assessment is to further assess the suitability of Topsoil and Made Ground material for reuse on site and to determine whether unacceptable risks exist to end users within should material be left in-situ.
- 7.1.3 Fieldwork observations on the potential for contamination and the underlying ground conditions did not identify any new contaminant sources to those identified in previous reports.

7.2 Laboratory Testing Rationale

- 7.2.1 Samples of the Topsoil and Made Ground were obtained and tested for the purpose of assessing the suitability of such soils for reuse onsite within private garden areas. As such generic screening values have been adopted based upon a 'residential with home grown produce' as a precaution.

7.3 Generic Assessment Criteria

- 7.3.1 Assessment of laboratory test data has been carried out using published generic assessment criteria (GACs). The GACs act as screening values to provide a 'trigger' to an assessor that soil concentrations above these limits might present an unacceptable risk.
- 7.3.2 Various GAC sources are used within this report. Key assumptions are made in the derivation of screening values in regard to their use and application, and exposure modelling is based on precautionary national scenarios. This generic approach can result in an overly conservative assessment; therefore, the assessor is required to review the outcome of the GQRA screening in the context of the site specific CSM and identified potential contaminant linkages.
- 7.3.3 Asbestos does not currently have published GACs which can be used for generic assessment purposes, at this stage a present / absent trigger limit has been adopted.
- 7.3.4 Specific details regarding the published GAC sources chosen and any parameter refinements made are summarised within Appendix I, along with the order of preference where multiple GAC sources are available. The exposure models adopted are discussed in the relevant sections below.

7.4 Human Health GQRA (Soils and Vapour)

- 7.4.1 The results of the human health screening assessment for soils and vapours are detailed in Appendix I. The following table outlines the exposure models adopted, along with summarising the outcome of each screening assessment.

Stratum	CLEA model	Inorganic contaminants	Organic contaminants
Topsoil (40No. samples analysed)		1No. exceedance of beryllium 2no. exceedances of lead	No exceedances
Made Ground (10No. samples analysed)	Residential with home grown produce	2No. exceedances of arsenic 1No. exceedance of beryllium 1No. exceedance of cadmium 1No. exceedance of lead 2No. exceedances of nickel 2No. positive results for chrysotile asbestos.	1No. exceedance of benzo(b)fluoranthene and dibenz(a,h)anthracene 1No. exceedance of TPH C16-C21

Table 7-A: Summary of chemical analysis

7.4.2 The table below summarises the instances where contaminants have exceeded the generic screening criteria.

Receptor	Strata	Contaminant	Locations & Depths	Test Result / Range (mg/kg)	GAC (mg/kg)
Residential with homegrown produce	Topsoil	Beryllium	TP03 0.10m	3.3	1.7
		Lead	TP17 0.10m SL14 0.10m	230 - 520	200
	Made Ground	Benzo(b)fluoranthene	SL02 at 0.10m	3.5	2.6
		Dibenzo(a,h)anthracene		0.48	0.24
		Arsenic	SL01 & SL02 at 0.10m	47-54	37
		Beryllium	TP19 at 0.10m	2.4	1.7
		Cadmium	SL02 at 0.10m	50	22
		Nickel	SL01 & SL02 at 0.10m	140 - 340	130
		EC>16-EC21 (unspeciated)	SL01 at 0.10m	500	260

Table 7-B: Human health GQRA exceedances

- 7.4.3 Minor exceedances of GAC values were recorded in topsoil samples, one relating to beryllium and two relating to lead. Multiple GAC exceedances and chrysotile asbestos were recorded in Made Ground samples SL01 and SL02. Only one other sample of Made Ground recorded any exceedance, relating to beryllium in TP19 at 0.1m depth.
- 7.4.4 Marginally elevated beryllium has been recorded in one topsoil sample (TP03 0.1m) and one sample of Made Ground (TP19 0.1m).
- 7.4.5 The existing guideline value for beryllium is based on research into the impact of industrial exposure, where the inhalation exposure route poses the most significant risk to end users. Indeed, the overwhelming majority of the existing literature strongly indicates that intake of beryllium orally through dermal contact has no ill health effects on humans and there is no evidence to suggest that naturally occurring beryllium poses a risk to end users.

- 7.4.6 As the site has not been subject to past industrial activities which are likely to have handled beryllium, concentrations recorded on site are likely to be naturally occurring. The average concentration of natural beryllium in the earth's crust is approximately 2-5mg/kg which notably exceeds the residential guideline value of 1.7mg/kg, derived by research into industrial exposure. On this basis, the recorded concentrations of beryllium are not considered to present a risk to human receptors.
- 7.4.7 Only 2No. out of the 40No. topsoil samples recorded exceedances of lead with one being very marginal (230mg/kg compared to a GAC of 200mg/kg). No sources of lead have been identified and the average concentration of lead sitewide within the topsoil was 72mg/kg, therefore stockpiling of topsoil will effectively 'dilute' the measured concentrations of lead, which are likely to be very localised and not prevalent on site.
- 7.4.8 On this basis the existing topsoil resources are considered suitable for reuse in a residential setting without any remedial action from a human health perspective.
- 7.4.9 With the exception of the one beryllium exceedance in TP19, all other GAC exceedances in Made Ground were measured from SL01 and SL02, where Made Ground was visible from the surface. Made Ground in this area did not appear to be laterally extensive and was only recorded to depths of 0.3m. Fibres of chrysotile asbestos were also identified in such soils, including paper/bitumen-based debris, quantified at a concentration of 0.008% to 1.8%.
- 7.4.10 As such it is recommended that the Made Ground in these areas is stripped and either reused beneath fill or hardstanding (effectively severing the pathway from source to site receptors), or disposed of off-site to landfill under the appropriate duty of care.

7.5 Risks to Soft Landscaping Vegetation

- 7.5.1 Analysis indicates that the Topsoil/Made Ground deposits may contain very localised metal concentrations (lead and copper) and elevated pH at levels which could pose a potentially phytotoxic risk to vegetation in the proposed planting scheme. The assessment excludes soils from the area of SL01 and SL02 given these soils will be removed from such areas. Exceedances in themselves don't necessarily constitute a requirement for remedial action, instead it is recommended that a landscape consultant is provided with the results to consider the potential impact on the proposed planting scheme and determine whether or not the materials could provide a suitable growing medium.

7.6 Construction Workers Risk Assessment

- 7.6.1 Analysis indicates that contaminant levels do not pose an acute risk to construction workers. In general, standard PPE and hygiene protocols for working on brownfield sites is considered adequate to mitigate against the potential risk from contaminants on site, and no special precautions are required.
- 7.6.2 Asbestos was largely absent across the site; however it was detected within the shallow Made Ground in the vicinity of SL01 and SL02 at very low to low concentrations (0.008 and 1.8%).
- 7.6.3 A risk assessment has been undertaken using the JIWG Decision Support Tool (see Appendix I), and at these concentrations, there is a medium risk to construction workers at the site from asbestos contamination where identified.

- 7.6.4 The presence of asbestos fibres in the area of SL01 and SL02 will require consideration in the construction phase health and safety plan. Special precautions are considered to be required in these areas, including the adoption of RPE (P3 half masks), the use of enhanced personnel decontamination facilities, in combination with localised mechanical dust suppression. Good working practices for working on brownfield sites and for dust mitigation should be adhered to at all times, including;
- Asbestos awareness training.
 - A watching brief during enabling works.
 - A site-specific asbestos awareness briefing as part of the site inductions.
 - Establishing an appropriate action plan in the event of encountering unexpected contamination and suspected asbestos containing materials.
 - Control of material movements to minimise dust generation, for example by reducing drop heights and ensuring buckets are not over-loaded.
 - Excavated materials should be dampened down.
 - Blading or covering short-term stockpiles.
 - Covering or seeding long-term stockpiles.
- 7.6.5 With the exception of asbestos, the risk posed to construction workers from other contaminants in the ground is considered low and providing standard PPE and hygiene protocols are maintained for working on brownfield sites, no further special precautions are required.

7.7 Controlled Waters GQRA

- 7.7.1 Groundwater is present at the site within underlying Hummocky Glacial Deposits, which appears to emerge locally at springs within the site, and likely provides base flow to the larger areas of surface water adjacent to the south.
- 7.7.2 Whilst the ground conditions and total concentrations of contaminants measured in soils at the site are unlikely to pose a risk to ground/surface water receptors, there is concern that the proposed development of the site may affect the quality of water flowing into the ponds, and thereby potentially adversely affecting aquatic life (some are used for fishing).
- 7.7.3 As part of the preliminary slope stability works package (ref Section 1.2.3) previously issued in March 2023, surface water was sampled at four spring locations onsite with subsequent laboratory testing to establish a baseline water quality within the site prior to any construction works. In addition, water quality measurements were taken insitu utilising a quality meter. Water quality measurements are presented in Appendix F and laboratory test data is presented in Appendix H. The locations of surface water samples are shown in the figure below.



Figure 7-A: Location of spring monitoring positions

- 7.7.4 Screening of baseline data with Environmental Quality Standards (EQS) presented in Appendix I indicates exceedances of guidelines for various metals, largely cadmium, chromium, copper and zinc, with localised marginal exceedances of nickel and lead. No elevated concentrations of PAHs were noted. Given the lack of sources of contamination onsite, such concentrations are likely to be indicative of natural background concentrations for surface waters in the area. It is also noted that guidelines for contaminants such as cadmium, copper and zinc are affected by the bioavailability parameters of the receiving water course. As such, the guideline values utilised within the current assessment are considered conservative for such contaminants.
- 7.7.5 Surplus materials generated during cut and fill works should be carefully managed during construction. Monitoring of the spring locations (where construction permits), and the adjacent ponds to the south, should be undertaken before, during and after construction of the basin, to ensure development it not causing detrimental impact to surface waters. If comparison of concentrations measured during constriction are significantly higher than baseline concentrations measured in samples from 2023 and pre-construction, works should be halted and an action plan determined and agreed with the EA accordingly.

7.8 Ground Gas Monitoring Rationale

- 7.8.1 Previous reporting undertaken by Smith Grant identified a small area of infilled land 40m northwest of the site as a source of landfill gas which may be able to migrate beneath the development area.
- 7.8.2 As such 4No. gas monitoring wells were installed in the north-western corner of the site, and a total of 6No visits are scheduled to be undertaken over a period of 6 months. To date 5No. rounds have been undertaken and the final version of the report will be updated to include all monitoring results on completion.

7.9 Ground Gas Monitoring Results

7.9.1 A summary of the gas monitoring results follows, with the full results detailed within Appendix F.

- Gas flow rates were detected up to 0.6 l/hr, but were generally observed below the limit of detection (0.1 l/hr).
- Steady concentrations of methane were recorded at or below the limit of detection of 0.1%, except for one location (WS04) where a steady concentration of 0.8% was detected (peak of 0.9%), however the well was flooded on all monitoring visits.
- Steady concentrations of carbon dioxide were in the range of 0.1% to 3.4%.
- Steady concentrations of oxygen were in the range of 18.6% to 21.4%.

7.10 Ground Gas Risk Assessment

7.10.1 The absence of methane and carbon dioxide indicates that there is no significant migration of ground gases occurring from nearby landfills. A CS-1 classification applies. This is an interim classification and the report will be updated on completion of the final gas monitoring visit.

7.11 Water Supply Pipes

7.11.1 A full site investigation as set out in the UK Water Industry Research (UKWIR) document '*Guidance for the selection of Water supply pipes to be used in Brownfield sites*' has not been undertaken.

7.11.2 The UKWIR document advises a trigger concentration of 0.125mg/kg for the 'extended VOC (volatile organic compounds) suite', which includes the PAH (polycyclic aromatic hydrocarbons) suite that has been included in the soil analysis during this investigation.

7.11.3 The maximum summed concentration of PAH congeners from individual samples obtained from the site at likely pipe depths (0.50m to 1.50m bgl) do not exceed the trigger concentration of 0.125mg/kg, and the proposed development is unlikely to pose a risk of future contamination, therefore the installation of protective barrier-pipes in below ground water infrastructure is unlikely to be required.

7.11.4 In all instances, it is advised to consult the water company for advice to determine if protective pipe is necessary or if further assessment and investigation works are warranted. Irrespective of the assessment made here, water companies may insist on barrier pipe being installed. Once the initial consultation has taken place, Soiltechnics can support you in any further assessments that may be required.

7.12 Risk Assessment Conclusions

7.12.1 The risk assessment has identified potential contaminant linkages which exceed the low-risk threshold and require further investigation, mitigation, or remediation. These are discussed in further detail below.

Contaminant Source	Receptor	Recommended Action	Discussion
Asbestos in shallow Made Ground local to SL01 & SL02	Construction workers	Mitigation	The risk to construction workers should be noted and included in risk assessments for the development of the site, with appropriate mitigation measures adopted while excavating in such areas.

Contaminant Source	Receptor	Recommended Action	Discussion
Asbestos in shallow Made Ground local to SL01 & SL02	End users	Remediation	Made Ground in the areas of SP1 & SP2 should be removed and reused below buildings/hardstanding, or below proposed fill.
Mobilisation of contamination from earthworks into surface waters	Controlled waters	Mitigation	Monitoring of the spring locations (where construction permits) and the adjacent ponds to the south, should be undertaken before, during and after construction, to ensure development it not causing detrimental impact to surface waters.

Table 7-C: Risk Assessment Conclusions

7.12.2 A Remediation Strategy must be established to detail the measures to be taken, along with including the verification plan for all necessary works.

7.12.3 Once all investigations and remedial works are completed, a Verification Report will then be required.

7.13 Ground Gas Protection Measures

7.13.1 For clarity, the requirement for ground gas protection measures is summarised in the table below.

Gas Type	Contaminant of Concern	Protection Measures Required?
Permanent Ground Gases	Methane/CO ₂	None required – pending completion of monitoring programme
Hydrocarbon Vapours	N/A	None required
Radon	N/A	None required

Table 7-D: Ground gas protection measures requirement

7.14 Unexpected and Previously Unencountered Contamination

7.14.1 With the development of any site, there is a residual risk of contamination being found that is unexpected or has not been encountered during investigation or other siteworks.

7.14.2 Should any previously unencountered and unexpected contamination be encountered, works should be temporarily halted and Soiltechnics informed. The Consultant should then assess the situation to determine what remedial action is required and inform the Local Authority at the earliest opportunity.

7.14.3 It is often a requirement of Local Authority planning conditions that the building/demolition contractor has a contamination discovery/contingency strategy in place for dealing with unexpected contamination. Soiltechnics are pleased to provide advice on such a strategy if required.

8 Soil and Waste Management

8.1 Sustainability

- 8.1.1 Where possible, disposal of soils to landfill should be avoided in preference for more sustainable alternatives. Such alternatives are set out below and rely on appropriate planning and design.
- 8.1.2 Soiltechnics can provide additional support and guidance to assist in overall material management and soil waste minimisation upon request.

8.2 Waste Hierarchy

- 8.2.1 Under the Waste Regulations, there is a requirement to apply (where reasonable) the waste management hierarchy, which is summarised below. Within the hierarchy, soil disposal to landfill should be limited to the necessary minimum.

Stage (in order of preference)	Example application
Prevention / Reduce	Design, planning, Site Waste Management Plans (SWMP).
Reuse	Reuse of soils under exemption, permit or Materials Management Plan (MMP), sorting at the point of excavation, screening of excavated material.
Recycling	Recycling aggregate, waste segregation, screening and sorting.
Recovery	Remediation works, transfer to a Soil Treatment Facility
Pre-treatment	Non-hazardous and hazardous soils do not need to be treated, where such treatment would not reduce the volume of waste.
Disposal	If the waste hierarchy steps outline above are followed, the remaining waste can be disposed of to a landfill without any further treatment.

Table 8-A: Waste management hierarchy

8.3 Liability of Waste Management

- 8.3.1 Part III of the Finance Act was amended in 2018 to extend the scope of landfill tax to cover any site (not exclusively landfills) operating without an appropriate environmental permit, exemption, or MMP.
- 8.3.2 These changes have given HMRC the powers to work with the Environment Agency to identify non-compliant sites and pursue and penalise the person(s) illegally disposing of waste, and anyone who knowingly facilitates the disposal. This includes sites filling site-won soils which are surplus to requirement.

8.4 Materials Management

- 8.4.1 In terms of the development, where reasonably practicable, landfill disposal should be minimised through the reuse of site-won materials on site, or off-site transfer of surplus soils to other development schemes or Soil Treatment Facilities. Early consideration of the site's overall material balance at the design stage is also critical in reducing the need for off-site disposal, limiting costs, and increasing the overall sustainability of the development.
- 8.4.2 Where Made Ground soils are to be reused onsite or materials transferred between sites, a Materials Management Plan (MMP) or Waste Exemption is recommended.

- 8.4.3 The process of an MMP allows soils that are suitable for reuse and have a certainty of use to not be considered a waste, and therefore not fall under the waste regulations. This scheme is self-regulated within the industry and is supported in principle by the Environment Agency.

8.5 Further Recommendations

- 8.5.1 As the reuse of Made Ground soils on site is likely to exceed 1,000 tonnes (U1 Exemption limit), it is recommended that the works are controlled under an MMP in accordance with the CL:AIRE DoW CoP. An effective MMP should help increase the sustainability of a development by reducing the requirement for landfill disposal and will serve to reduce the overall liability the developer holds over managing waste and site-won soil arisings.
- 8.5.2 Should surplus Made Ground be disposed of off-site to landfill it is recommended to undertake additional sampling and testing during the construction works to fully characterise the waste soils intended for disposal. The overall frequency of testing should be dependent upon the composition, volume and variability of the material excavated.

9 Recommendations for Further Works

9.1.1 The following table summarises the additional works which should be undertaken prior to commencement of any construction works and in support of the planning conditions.

Aspect	Delivered By	Description	Necessity
Remediation Strategy	Soiltechnics	A Remediation Strategy is required to detail the requirements and verification plan for all remedial works, including surface water compliance testing.	REQUIRED
Discovery Strategy	Principal Contractor	The Principal Contractor should have a discovery strategy in place in the event of exposing unexpected or previously unencountered contamination. Soiltechnics should be informed at the earliest opportunity to undertake an assessment, and to inform the Local Authority as appropriate.	REQUIRED
Materials Management Plan	Soiltechnics	Once the overall designs and cut-and-fill requirements for the scheme have been finalised, and before excavation works commence, an MMP is recommended to facilitate the reuse of soils on site and the transfer of materials on or off-site.	RECOMMENDED
Waste disposal	Soiltechnics	Any Made Ground which is not reused onsite and requires disposal should be classified accordingly to fully characterise the waste soils intended for disposal.	RECOMMENDED
Detailed (design) Investigations	Soiltechnics	If SUDS are considered, it is recommended that in situ testing within this stratum is undertaken during completion of the earthworks phase of the development to facilitate a quantitative assessment. The in-situ testing should be undertaken in accordance with in BRE 365: Soakaway Design (2016). It is recommended that the design CBR values are validated with in situ testing immediately prior to construction.	OPTIONAL

Table 9-A: Recommended further works (pre-commencement)

9.1.2 The following table summarises the additional works which should be undertaken during the enabling and construction works phases to support the safe development of the site.

Aspect	Delivered By	Description	Necessity
Undertaking remedial works	3 rd Party	Undertaking the works, as specified within the Remediation Strategy. Remedial works are expected to comprise removal of Made Ground in the areas of SL01 and SL02, and either reuse onsite below buildings/hardstanding/fill, or disposal offsite.	REQUIRED
Verification of remedial works	Soiltechnics	All remedial works must be witnessed and evidenced by a geoenvironmental consultant to demonstrate compliance to the Remediation Strategy, with a Verification Report produced to demonstrate compliance.	REQUIRED
Surface Water compliance testing	Soiltechnics	Monitoring of the springs/ponds should be undertaken before, during and after construction, to ensure development it not causing detrimental impact to surface waters.	REQUIRED

Aspect	Delivered By	Description	Necessity
Verification of the MMP	Soiltechnics	If a Materials Management Plan is undertaken, the earthworks and material movements on site must be witnessed and evidenced by a geoenvironmental consultant, with a Verification Report produced to demonstrate compliance.	RECOMMENDED

Table 9-B: Recommended further works (enabling works & construction phase)