



Phase 2 Ground Investigation Report

Land West of Bankfield Drive
Holmbridge, Holmfirth, HD9 2PH, West Yorkshire

for

Orion Homes Limited

G-22-009

April 2022

Revision	Issue date	Report status, changes made	Author	Reviewer
0	27/4/22		DJW	GVR

Registered office
37-38 Market Street
Ferryhill
DL17 8

t: 07795 616 513
e: grantvrhardson@gmail.com

Company Registration No. 12773474

GVR Geoservices

Contents

Executive Summary

1.0	Introduction	1
2.0	Summary of Previous Reports	2
3.0	Fieldwork & Laboratory Testing	5
4.0	Ground Conditions.....	6
5.0	Contamination Assessment.....	10
6.0	Revised Conceptual Site Model	11
7.0	Remediation.....	13
8.0	Geotechnical Appraisal	14

Appendix A - Drawings

Appendix B - Exploratory Hole Logs

Appendix C - Geotechnical and Soakaway Test Results

Appendix D - Chemical Test Results

Appendix E - GVR Geo Generic Assessment Criteria

Executive Summary

The executive summary should not be read or used in isolation and reference should be made to the full report which provides a detailed assessment of the risks potentially affecting the development.

Ground Conditions	The investigation revealed topsoil overlying residual soils (completely weathered bedrock) in turn overlying bedrock at 0.5m to 3.5m bgl comprising sandstone (Upper Kinderscout Grit) below the northern two thirds of the site and shale (Marsden Formation) below the southern third. The residual soils below the northern area include medium dense silty gravelly sands with occasional firm sandy gravelly silts. In the southern area the residual soils predominantly comprise soft to firm becoming firm to stiff sandy clays and silts. Below the residual soils the highly weathered bedrock comprises medium strong sandstone below the northern area and extremely weak shale below the southern half. No significant visual/olfactory evidence of contamination was encountered.
Groundwater	Groundwater was not encountered by the ground investigation. The main groundwater table is likely to occur at depth within the bedrock. Evidence of ephemeral springs was noted at a location within the centre of the site which are likely to be associated with sporadic spring issues occurring during periods of heavy and persistent rainfall.
Contamination and Remediation	Localised marginally elevated lead was found in a sample of the topsoil. This contaminant is not considered to pose an unacceptable risk to the human health of the end users of the development. No remedial actions to deal with the low risk proven soil contaminants are considered necessary.
Waste Classification	All excess soil arisings of natural soils are likely to be inert for waste disposal purposes.
Ground Gas	Gas protection measures and radon protection measures are not required.
Foundations and Floors	Traditional strip foundations founded within the firm clays/silts or medium dense sands of the residual soils or bedrock at a minimum depth of 0.85m below existing ground level are recommended. Foundations may need to be stepped due to the slope of the site and where foundations extended across varying ground comprising both clays/silts, sands or bedrock they should be reinforced, Ground bearing floor slabs or suspended floors are recommended. However, where different soils/bedrock occur beneath floor areas a reinforced ground bearing slab should be used.
Roads and Pavements	For road and pavement design a design CBR value of 2% is considered appropriate for the residual soil clays/silts. A CBR design value of 5% would be appropriate for the northern two thirds on the basis that any silts encountered at formation level are excavated and replaced with engineered granular fill.
Excavations and Trenches	Shallow excavations within the residual soils/highly weathered bedrock are likely to be achievable using conventional plant. Where deeper excavations are required extending into less weathered bedrock, pneumatic breakers may be required. Although no groundwater table was identified in the exploratory holes during the site works, isolated perched groundwater horizons in the residual soils cannot be completely discounted. Where such conditions are encountered, excavations may require temporary trench support and sump pumping.
Concrete Classification	Buried concrete should be designed to BRE Special Digest 1:2005 Design Sulphate Class DS-1 with an ACEC site classification AC-1s.
Drainage	In-situ testing has revealed that the site may be suitable for soakaway drainage systems below the northern two thirds of the site which is underlain by sandstone. The suitability of soakaway drainage would be subject to annual groundwater level variation. Positive



	drainage should be provided in the area of an ephemeral spring to prevent future surface spring issues during high rainfall.
Slope Stability and Retained Structures	The northern site boundary comprises a stone retaining wall supporting site levels. The long term structural integrity of this wall should be assessed.

1.0 Introduction

1.1 Commission

GVR Geoservices Ltd (GVR Geo) was commissioned by Orion Homes Limited to undertake a Phase 2 Ground Investigation for the proposed development of a plot of land west of Bankfield Drive in the village of Holmbridge, near Holmfirth, West Yorkshire, HD9 2PH. A site location plan is presented as Drawing No. G-22-009-001 in Appendix A.

1.2 Proposals

It is understood that the proposed development will comprise the construction of 25 houses with associated access roads and private gardens. The current development proposals are shown on Orion Homes Drawing No. 2021.01.003 Rev E in Appendix A.

This report is required to support the pre-acquisition site appraisal and potentially to support a subsequent planning application.

1.3 Objectives

The objectives of the ground investigation were:

- Inspect the ground for evidence of made ground and potential contamination, take soil samples for chemical laboratory testing, with particular reference to the recommendations in the Desk Study Report, as referenced below.
- Undertake contaminated land risk assessment for the proposed end use.
- Prove shallow ground conditions for foundation design considerations.
- Undertake in-situ geotechnical tests and obtain soil samples for laboratory geotechnical testing.
- Undertake infiltration testing to obtain the parameters for soakaway drainage design.
- Install ground gas and groundwater monitoring wells and undertake a programme of monitoring to allow ground gas risk assessment for the proposed buildings.
- Provide a factual and interpretive report with recommendations for foundation design and mitigation measures for any proven contamination.

1.4 Information Sources

The following report has been used to determine the initial design of the Phase 2 ground investigation and to define the preliminary conceptual site model (CSM) in this report:

- Phase 1 Geoenvironmental Desk Study, Land West of Bankfield Drive, Holmbridge, Holmfirth, HDP 2PH West Yorkshire. GVR Geoservices Ltd, Ref. G-22-009, March 2022.

1.5 Limitations

This report has been prepared for Orion Holmes Limited only and should not be relied upon by any third party without the written permission of GVR Geo. If any unauthorised third party comes into possession of this report, they rely on it at their own risk and the authors do not owe them any Duty of Care or warranty of Skill. This report is based on and limited to an assessment of the information and ground conditions identified here. GVR Geo is not responsible for ground conditions not revealed during these investigations.

2.0 Summary of Previous Reports

The following is a summary of the salient findings of the Phase 1 Desk Study and should not be read in isolation. For full details, reference should be made to the original report.

Site Description	The site comprises a rectangular plot of land currently set to rough pasture which slopes down to the north at gradients of around 1 in 10. Site levels vary from approximately 214m AOD on the southern boundary to 200m AOD on the northern boundary. The site is bound to the east, south and west by dry stone walls. The northern boundary falls away to the north at a steeper angle and is vegetated with semi-mature trees planted above a stone retaining wall adjacent to Dobb Top Road lying below the site level with a retained height of approximately 2m. Access is gained via the hammerhead turning at the western end of Lathe Avenue located in the south east corner of the site. The adjacent land is occupied by residential properties to the east and open farmland to the south and west. The land to the north comprises Dobb Top Road with residential development and the village of Holmbridge in the valley bottom below. There is a stable block and residential buildings adjacent the north west corner.
Site History	The site is recorded to have been used as farmland since the earliest available OS map of 1854. The outlying area has historically included woollen mills, dye houses and a silk/sealskin factory in Holmbridge 50m to 100m north and north west.
Geology	No superficial deposits are recorded on site by the British Geological Survey (BGS). However, superficial deposits comprising sandy clays up to around 2m in depth are recorded on historical borehole records in other such areas within the vicinity of the site and are anticipated on this site. The solid geology is anticipated to comprise strata of the Upper Carboniferous Millstone Grit Group. The BGS records indicate these strata to include sandstone of the Upper Kinderscout Grit underlying the northern half of the site and mudstone/siltstone of the younger Marsden Formation underlying the southern half.
Environmental	<i>Surface Waters</i> There are no surface water bodies within or adjacent to the site. The nearest surface water body comprises the River Holme 40m NW of the site. There are no nearby surface water abstractions. <i>Groundwaters</i> The underlying Millstone Grit bedrock is classed as a Secondary A Aquifer of high groundwater vulnerability.

	The site does not lie within a source protection zone and the nearest groundwater abstraction is located 399m E. During the site walkover survey evidence of an ephemeral spring was identified as shown on Drawing No. G22-009-002, Appendix A.
Flooding	The site is not within a flood zone 2 or 3 and is recorded to be at a negligible risk of both surface water and groundwater flooding.
Contaminants	There is a low risk of potential significant contaminants of concern being present, associated with the agricultural land use of the site and historical land use of the adjacent land including farms, woollen mills and dye industries. No specific contaminants of concern are anticipated. Potential contaminants include low concentrations of polyaromatic hydrocarbons (PAHs), heavy metals, water soluble sulphates and asbestos containing materials (ACMs).
Ground Gas	There are no records of current or recent landfilling within 500m and radon protective measures are not required for dwellings in the area. The site is not considered to be at risk of being affected by ground gas from on site or adjacent sources.
Drainage	The sandstone bedrock recorded to underlie the northern half of the site may be suitable for soakaway drainage systems.

2.1 Preliminary Conceptual Site Model

The preliminary Conceptual Site Model (CSM) from the Phase 1 report is provided below.

Source	Pathway	Receptor	Contaminant Linkage: Assessed Risk
Human Health			
Potential off-site sources of mobile groundwater contaminants.	No significant off-site sources, so no plausible pathways.	End users	Low Off-site sources are predominantly north of the site in the valley below and down hydraulic gradient. No mitigation anticipated.
Ground gas associated with nearby off-site sources.	No significant off-site sources, so no plausible pathways	End users	Low No mitigation anticipated.

Source	Pathway	Receptor	Contaminant Linkage: Assessed Risk
Controlled Waters			
No significant contaminants anticipated on site.	No significant off-site sources, so no plausible pathways	Secondary A Aquifer (Bedrock) Surface Water (River Holme)	Low No mitigation anticipated. Low No mitigation anticipated.

3.0 Fieldwork & Laboratory Testing

Based on the findings of the Desk Study, the following scope of fieldwork and laboratory analysis was undertaken:

- Drilling of 6 No. window sample boreholes (WS1-6) using a track-mounted dynamic sampling rig to depths of between 1.1-4.0m, to assess shallow ground conditions.
- 4 No. soakaway trial pits (SK1-4) by mechanical excavator to depths of 0.9-2.3m with subsequent adjacent soakaway test pits SK1A to SK4A undertaken at a later date once a source of water was available for carrying out the tests.
- Contamination testing of 6 No. samples of topsoil ground for a suite of parameters comprising: heavy metals, metalloids, non-metals, inorganics, speciated polyaromatic hydrocarbons (PAHs) and asbestos.
- Geotechnical testing of 3 No. soil samples their natural moisture content and Atterberg Limits, and 6 No. soil samples for their water-soluble sulphate content and pH.

The fieldwork was undertaken between 15th and 16th March 2022. An exploratory hole location plan is included as Drawing No. G-23-009-002 in Appendix A, and copies of the exploratory hole records are provided in Appendix B. Geotechnical and soakaway test results are presented in Appendix C and chemical test results are presented in Appendix D.

3.1 Exploratory Hole Rationale

Based on the findings of the desk study and the preliminary CSM, the location of the exploratory holes was based on the following rationale.

Exploratory Hole	Rationale
WS1 and WS6	Site-wide ground conditions including the absence or presence of superficial deposits and the potential variation of the bedrock strata depicted by the BGS records.
SK1 to SK4 (Tests SK1A – SK4A)	Ground conditions and infiltration rates of the near surface strata for soakaway drainage suitability assessment targeting the suitability of the sandstone strata recorded to potentially underlie the northern half of the site, and the mudstone/siltstone strata below the southern half.

4.0 Ground Conditions

4.1 Soil Profile

The results of the site investigation have indicated the ground conditions to comprise two distinct strata profiles. The approximate northern two thirds of the site are underlain by more granular deposits associated with the Upper Kinderscout Grit strata and the southern third of the site comprises predominantly cohesive/fine grained deposits associated with the Marsden Formation strata. The principal strata types encountered for each of these distinct areas are summarised as follows.

Depth Range to Top of Strata, mbgl (Thickness, m)	Strata Type
Ground Level (0.20 - 0.35)	TOPSOIL (Entire Site): Dark brown clayey silty very sandy with rootlets.
	NORTHERN TWO THIRDS
0.25 – 0.35 (0.65 – 1.12)	Residual Soil of Weathered Bedrock - Upper Kinderscout Grit Medium dense becoming very dense orange grey clayey silty fine to medium SAND with fine to coarse subangular to angular gravel of sandstone lithorelics. Occasional sandstone cobble lithorelics. Occasional layers of 'firm to stiff' yellow brown sandy silt with gravel of sandstone lithorelics.
0.50 – >2.00	Highly Weathered Bedrock – Upper Kinderscout Grit Medium strong pale yellow silty fine to coarse SANDSTONE with sand infilled discontinuities.
	SOUTHERN THIRD
0.20 – 0.25 (1.70 – 3.25)	Residual Soil of Weathered Bedrock – Marsden Formation 'Soft to firm and firm becoming firm to stiff pale yellow silty slightly sandy CLAY and yellow mottled orange clayey slightly sandy SILT, occasionally laminated with pale brown silt partings.
3.50	Highly Weathered Bedrock – Marsden Formation Extremely weak pale grey mottled orange brown thinly laminated silty SHALE with brown stained discontinuity surfaces.

The approximate strata boundary between the Upper Kinderscout Grit and Marsden Formation is shown on Drawing No. G-23-009-002 in Appendix A.

4.2 Material Properties

Entire Site

4.2.1 Topsoil

Natural sandy clay topsoil was encountered at the ground surface in all the exploratory holes ranging in thickness from north 0.20-0.35m.

Northern Two Thirds

4.2.2 Residual Soil of Weathered Bedrock – Upper Kinderscout Grit

Residual soils of the weathered Upper Kinderscout Grit were encountered below the topsoil surface layer in the exploratory holes located within the northern two thirds of the site. These strata predominantly comprised clayey silty sands with gravel size sandstone lithorelics and occasional layers of sandy gravelly silt.

The results of three moisture content tests undertaken on the sands gave natural moisture contents of between 10.5% and 19%. The result of a single moisture content tests undertaken on the silts gave a natural moisture content of 20.2%.

The results of a single Atterberg Limit test performed on a sample of the clayey sandy silt layer gave a Liquid Limit of 32% and a Plastic Limit of 19%. Based on these results, a Plasticity Index of 13% is calculated. In addition, the percentage of materials passing the 425micron sieve was measured at 74%, giving a Modified Plasticity Index of 10%, indicating these soils to be of low to intermediate plasticity and low volume change potential.

The results of a single SPT test undertaken in the clayey sandy silts strata gave an SPT N value of 15. Using CIRIA Report 134, 1995 'The standard penetration test (SPT): methods and use', this N-value gives an equivalent undrained shear strengths of 75kPa and medium to high strength soils.

Water soluble sulphate tests on 4 samples of the residual soils of the Upper Kinderscout Grit recorded a range of <10 - 115mg/l and pH values of between 6.2 and 7.3.

4.2.3 Highly Weathered Bedrock – Upper Kinderscout Grit

Below the Residual Soil, highly weathered sandstone of the Upper Kinderscout Grit was encountered at depths between 0.50m and >2.00m below ground level. These strata were described as moderately strong pale yellow very thinly to thinly bedded fine to coarse sandstones that comprised sandstone lithorelics indicating a high degree of weathering.

The results of four SPT tests undertaken at the top of the sandstone all resulted in test refusals each achieving 50 test blows with test penetrations varying between 210mm and 295mm.

Southern Third

4.2.4 Residual Soil of Weathered Bedrock – Marsden Formation

Residual soils of the weathered Marsden Formation bedrock were encountered below the topsoil surface layer in the exploratory holes located within the southern third of the site. These strata predominantly comprise 'soft to firm' and 'firm becoming firm to stiff' pale yellow silty slightly sandy clays with occasional layers of yellow mottled orange clayey slightly sandy silt. Both were recorded to be occasionally laminated with pale brown silt partings.

The results of two Atterberg Limits test performed on samples of the clayey sandy silt layers gave Liquid Limits of 41% and 47% and Plastic Limit of 25% and 24% respectively. Based on these results, a Plasticity Indices of 16% and 23% are calculated. In addition, the percentage of materials passing the 425micron sieve was measured at 76% and 74%, giving Modified Plasticity Indices of 12% and 17% and indicating these soils to be of intermediate plasticity, but low volume change potential.

The results of four moisture content tests undertaken on the clay/silts gave natural moisture contents of between 18.2% and 27.3%.

The results of five SPT tests undertaken in the clayey sandy silt and silty clay strata gave SPT N values of between 10 and 24, but generally between 10 and 13. Using CIRIA Report 134, 1995 'The standard penetration test (SPT): methods and use', these N-values give equivalent undrained shear strengths of generally between 50kPa and 65kPa, occasionally increasing to 120kPa indicating predominantly medium and occasionally high strength soils.

The results of three hand shear vane tests undertaken within the upper layers of the silts/clays gave undrained shear strengths of between 36kPa to 70kPa indicating low to medium strength conditions above a depth of 0.85m bgl.

Water soluble sulphate tests on two samples of the residual soils of the Marsden Formation residual soils recorded <10mg/l and pH values of 4.7 and 5.8.

4.2.5 Highly Weathered Bedrock – Marsden Formation

Below the residual soils of the completely weathered Marsden Formation, highly weathered bedrock was encountered comprising extremely weak shale. The shale was described as varying between dark grey/black and pale grey mottled orange brown thinly laminated shale with iron stained fissure surfaces. The laminations were occasionally weathered to stiff clay indicating a high degree of weathering.

The results of a two SPT tests undertaken in the shales all resulted in test refusals each achieving 50 test blows with test penetrations of 265mm and 295mm.

4.3 Groundwater

All the exploratory holes remained dry during drilling and excavation. However, evidence of an ephemeral spring located at ground level within was noted during the site works, although the spring remained dry and no groundwater issues were noted during the fieldwork. This evidence of spring issues is located close to what appears to be the strata boundary between the Marsden Formation and Upper Kinderscout Grit and is likely to be the result of temporary surface infiltration during prolonged heavy rainfall rather than permanent seepage from a shallow continuous groundwater body.



4.4 Visual and Olfactory Contamination

There was no evidence of visual and olfactory contamination and no asbestos containing materials were observed within the soils during the investigation.

4.5 Obstructions

Cobbles were encountered in WS3 and trial pits SK2 and SK3 within the sands of the completely weathered Upper Kinderscout Grit residual soil. However, these did prove an excavation problem for the JCB 3CX machine excavator.

In addition, the highly weathered sandstone bedrock in WS1-3 was impenetrable at shallow depths with the window sampler and become hard to dig at shallow depths in SK2-4 with the toothed bucket of JCB.

5.0 Contamination Assessment

5.1 Generic Risk Assessment for Human Health

The assessment involves the screening of the measured concentrations of potential contaminants of concern obtained during the investigation against published generic assessment criteria (GAC) values which are representative of a 'minimal' or 'tolerable' risk to human health. The assessment criteria adopted are the LQM/CIEH Suitable for Use Levels (S4ULs) for Human Health Risk Assessment. Where no S4UL is available, reference is made to other relevant standards as appropriate.

A total of 6 topsoil samples were tested from the selection of parameters noted above to allow an assessment of potential contaminants of concern.

Based on the proposed end use, GACs for a 'residential with homegrown produce' end-use have been adopted. The soil organic matter content was calculated to be 5%, based on the average TOC concentration determined. A summary assessment table of all chemical test results and the GACs used is presented in Appendix E.

5.1.1 Metals, Metalloids, Non-metals

A single slightly elevated concentration of lead (340mg/kg) above the GAC value (200mg/kg) has been recorded in the topsoil sample from WS2. There was no evidence of anthropogenic materials being present in this sample.

Statistical analysis of the lead data reveals that the elevated sample is not a statistical outlier and is therefore part of the overall sample population. This is consistent with the field observations that this topsoil sample was texturally the same as the rest of the topsoil observed on site. The upper bound value (US95) for lead from all 6 samples is 81mg/kg, which is below the 200mg/kg GAC, meaning that the single elevated sample test result does not pose an unacceptable risk to end users.

5.1.2 Inorganics

There were no exceedences of these parameters in the samples tested.

5.1.3 Polycyclic Aromatic Hydrocarbons

There were no exceedences of these parameters in the samples tested.

5.1.4 Asbestos

No asbestos fibres were detected in the samples tested.

5.2 Controlled Waters Risk Assessment

Given the absence of any significant leachable made ground or mobile contaminants being found on site, and the low risk to controlled water receptors, no soil leachate or groundwater testing was carried out.

6.0 Revised Conceptual Site Model

The preliminary CSM presented in the Desk Study Report has been revised, based on the findings of this ground investigation. The revised CSM is presented below. Risk to human health or environmental receptors is based on an assessment of one or more contaminant source-pathway-receptor linkages. The contaminant 'source' is any substance which has the potential to cause significant harm to a relevant receptor and the 'pathway' is any route by which contamination may travel to impact on a 'receptor'. The revised CSM summarises the proven contaminant sources, pathways and receptors for this site and the likelihood of the existence of a plausible contaminant linkage.

The significance of the potential source-pathway-receptor linkages identified in the CSM is assessed using the following criteria:

Low Risk

Not likely to cause significant harm to human health or controlled waters. Remedial measures are unlikely to be required.

Moderate Risk

Possible significant harm to human health or controlled waters could occur depending on site specific circumstances. Remedial measures may be required.

High Risk

It is likely that significant harm to human health or controlled waters will occur unless appropriate remedial measures are incorporated into the development.

Revised Conceptual Site Model

Source	Pathway	Receptor	Contaminant Linkage: Assessed Risk
Human Health			
Isolated marginally elevated lead in topsoil.	Direct contact and ingestion/inhalation of contaminated soil and dust.	Construction workers	Low No mitigation measures considered necessary.
	Direct contact and ingestion/inhalation of contaminated soil and dust. Ingestion of home-grown vegetables.	End users	Low No mitigation measures considered necessary.

Source	Pathway	Receptor	Contaminant Linkage: Assessed Risk
Controlled Waters			
Isolated marginally elevated lead in topsoil.	Vertical and lateral migration to groundwater.	Secondary A Aquifer (Bedrock)	Low No mitigation measures considered necessary
		Surface Water (River Holme).	Low No mitigation measures considered necessary

7.0 Remediation

7.1 Contaminants of Concern

The generic risk assessment and statistical analysis of the data has confirmed that the isolated marginally elevated lead found in a sample of topsoil in WS2 does not pose an unacceptable risk to the end users of the development.

There was no evidence of visual or olfactory contaminants within the soils.

7.2 Remedial Actions

No remediation mitigation measures or considered necessary to deal with the isolated elevated lead concentration within the topsoil which is suitable for re-use in the private gardens of the development.

7.3 Gas Protection Measures

There are no significant gassing source on site or nearby so ground gas monitoring and gas mitigation measures are not considered necessary.

The site does not lie within an area where radon protection measures are currently required.

7.4 Utilities

The results of this assessment should be provided to the relevant water utility provider for their approval in advance of construction.

7.5 Waste Disposal

Notwithstanding comments in Section 7.2, any excess materials which the client intends to discard as part of the construction of the development would be classed as waste and must be appropriately handled in accordance with current Waste Legislation. The developer should be aware of and utilise the waste hierarchy where possible – Reduce → Reuse → Recycle → Recovery → Disposal. Where materials are unable to remain on site and disposal is the only option the waste should be classified and sent to an appropriate waste receiving facility. Waste Acceptance Criteria (WAC) testing would be required by the waste receiving facility prior to disposal.

For waste disposal purposes, it is considered that the natural soils will be classified as inert, but should be subject to re-testing prior to off-site disposal or treatment, as required by the receiving waste disposal site operator.

If any materials are to be removed from site, this should be undertaken in accordance with Duty of Care Regulations, 1991 and the Hazardous Waste Regulations, 2005.

8.0 Geotechnical Appraisal

8.1 Foundations

It is understood that the proposed development will comprise the construction of 25 houses with associated access roads and residential gardens.

The results of the ground investigation have indicated the site to be underlain by a sequence of topsoil overlying residual soils (completely weathered bedrock) which are in turn underlain by the highly weathered bedrock at depths between 0.5m and 3.5m bgl. The bedrock comprises two strata formations, the Upper Kinderscout Grit (sandstone) underlying the northern two thirds of the site and the Marsden Formation (shale) underlying the southern third.

The weathering of the two types of bedrock has resulted in the residual soils below the northern two thirds of the site to comprise predominantly silty gravelly sand with layers of sandy silt, and below the southern third predominantly silts/clays.

Based on the results of the in situ and laboratory geotechnical testing it is recommended that the proposed development should be founded on traditional strip foundations within the firm/medium dense residual soils designed to an allowable bearing capacity of 100kPa. At these load intensities total and differential settlements would be limited to <25mm and <1 in 500 respectively. However, where foundation excavations encounter both granular and cohesive soils or bedrock at foundation depth, strip foundations should be reinforced.

In accordance with NHBC chapter 4.2 (2021) foundations bearing onto the low volume change potential silt/clay should be placed at a minimum 0.85m depth for foundations within the zone of influence of new tree and shrub planting. In view of the variable nature of the residual soils across the site, including soft to firm cohesive silt layers within the northern gravelly sands, foundations may need to extend below this minimum depth to ensure that the foundation bears onto on firm/medium dense strata.

In view of the slope of the site, strip foundations may need to be stepped. Foundations should be designed by a competent structural engineer in accordance with NHBC Chapter 4.2 (2021).

8.2 Floor Design

Ground bearing floor slabs or suspended floors are considered appropriate. However, where the ground conditions differ across the footprint area of the property, ground bearing slabs should be reinforced.

8.3 Roads and Pavements

The current proposed layout shows a new access driveway extending from the existing access on the south east boundary of the site. It is assumed that the finished road pavement levels will be broadly as exist at present and formation levels are likely to be within the residual soils.

In general accordance with 'Interim Advice Note 73/06 rev 1 (2009) Design Guidance for Road Pavement Foundations (Draft HD25)' and the results of Atterberg soil plasticity tests, a design CBR of 2% is considered appropriate for the residual soils. However, the northern two thirds of the site have been identified to comprise both sands and silts associated with the Residual Soils of the Upper Kinderscout Grit. In this area, on the basis that any silts encountered at

formation level are removed and replaced with engineered granular fill, a CBR design of 5% is considered appropriate.

The approximate strata boundary between the Upper Kinderscout Grit and Marsden Formation across the site is shown on Drawing No. G-23-009-002 in Appendix A.

8.4 Excavations and Trenches

Shallow foundation and utility excavations within the residual soils and highly weathered bedrock should be achievable using conventional plant. Where deeper excavations are required extending into the less weathered bedrock, pneumatic breakers may be required.

In view of the granular and fissured nature of residual soils and highly weathered bedrock excavations may require temporary support designed in accordance with CIRIA Report 97 Trenching Practice (2nd Edition 2001).

No groundwater was encountered during the site works. However, isolated zones of perched groundwater cannot be completely discounted and temporary shallow perched groundwater may be encountered during periods of high rainfall. Where groundwaters are encountered temporary sump pumping would be adequate to maintain dry conditions for construction.

8.5 Concrete Classification

Water soluble sulphate tests on samples of residual soils recorded soluble sulphate contents of between <10 and 115mg/l and pH values of between 4.7-7.3. A design sulphate class of DS-1 and ACEC class of AC-1s is recommended in accordance with BRE Special Digest 1 (2005).

8.6 Drainage

The soakaway test results are summarised below and the calculation sheets are provided in Appendix C.

Test Pit	Infiltration Rate (m/s)				Comments
	Test 1	Test 2	Test 3	Design Value	
SK1A	0	ND	ND	0	Non-compliant test. No measurable infiltration after 4.25 hours.
SK2A	1.4	1.2	1.1	1.1	Test water soaked away as quickly as it discharged into pit.
SK3A	2.9x10 ⁻⁵	1.0 +	9.1x10 ⁻¹ +	9.1x10 ⁻¹	Test cycle 2 and 3 water effectively soaked away as quickly as it discharged into pit
SK4A	5.5x10 ⁻⁶ *	1.4x10 ⁻⁵ *+	ND	N/A	Non-compliant test. Result based on volume of water soaked, time of test and pit area tested.

+ Pits deepened during testing to expose more bedrock strata

- * Non-compliant test to BRE 365: 2016. Results based on amount of water soaked over area tested. Strata not suitable for soakaways.
- ND Not determined due to insufficient time to achieve a BRE 365 compliant test

The results of soakaway testing has indicated that the Upper Kinderscout Grit strata located below the northern two thirds of the site are likely to be suitable for soakaway drainage subject to annual changes in groundwater levels. Soakaway tests in the Marsden Formation shale in the southern third of the site indicate that these strata are not suitable for soakaway drainage systems.

During the ground investigation evidence of an ephemeral spring was noted within the central area of the site, as shown on Drawing No. G-23-009-002 in Appendix A. It is recommended that the drainage design for the site should include for positive drainage in this area to prevent future surface spring issues affecting properties during periods of high rainfall. The positive drainage should be tied-in to any proposed soakaway drainage scheme adopted for the site.

8.7 Slope Stability and Retained Structures

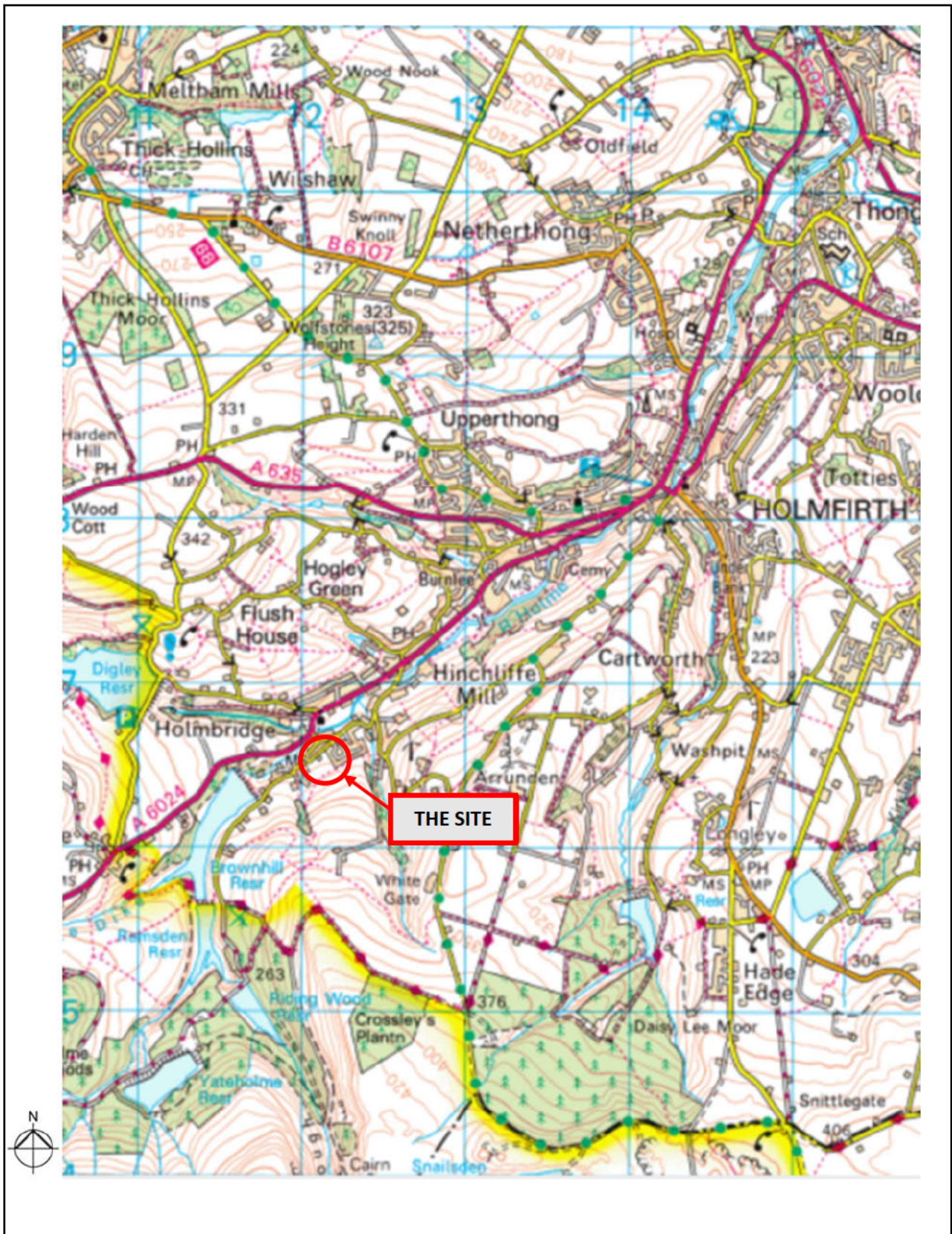
The site slopes at gradients of between 1 in 6 and 1 in 10 towards the northern boundary of the site and therefore some ground reprofiling will be required to provide level platform for building footprints. However, it is not envisaged that significant retaining structures will be required.

There is an existing retaining wall located along the northern site boundary with a retained height in the order of 2m, supporting the northern end of the site. The structural integrity of this wall and its suitability for the long term support of the site and proposed adjacent properties/gardens should be assessed. In considering the future stability of the wall, the potential impact of soakaway drainage systems during heavy rainfall should be considered, as the strata are effectively sub-horizontally bedded and build-up of infiltrating soakaway drainage water may occur behind the wall if the wall is inadequately drained.

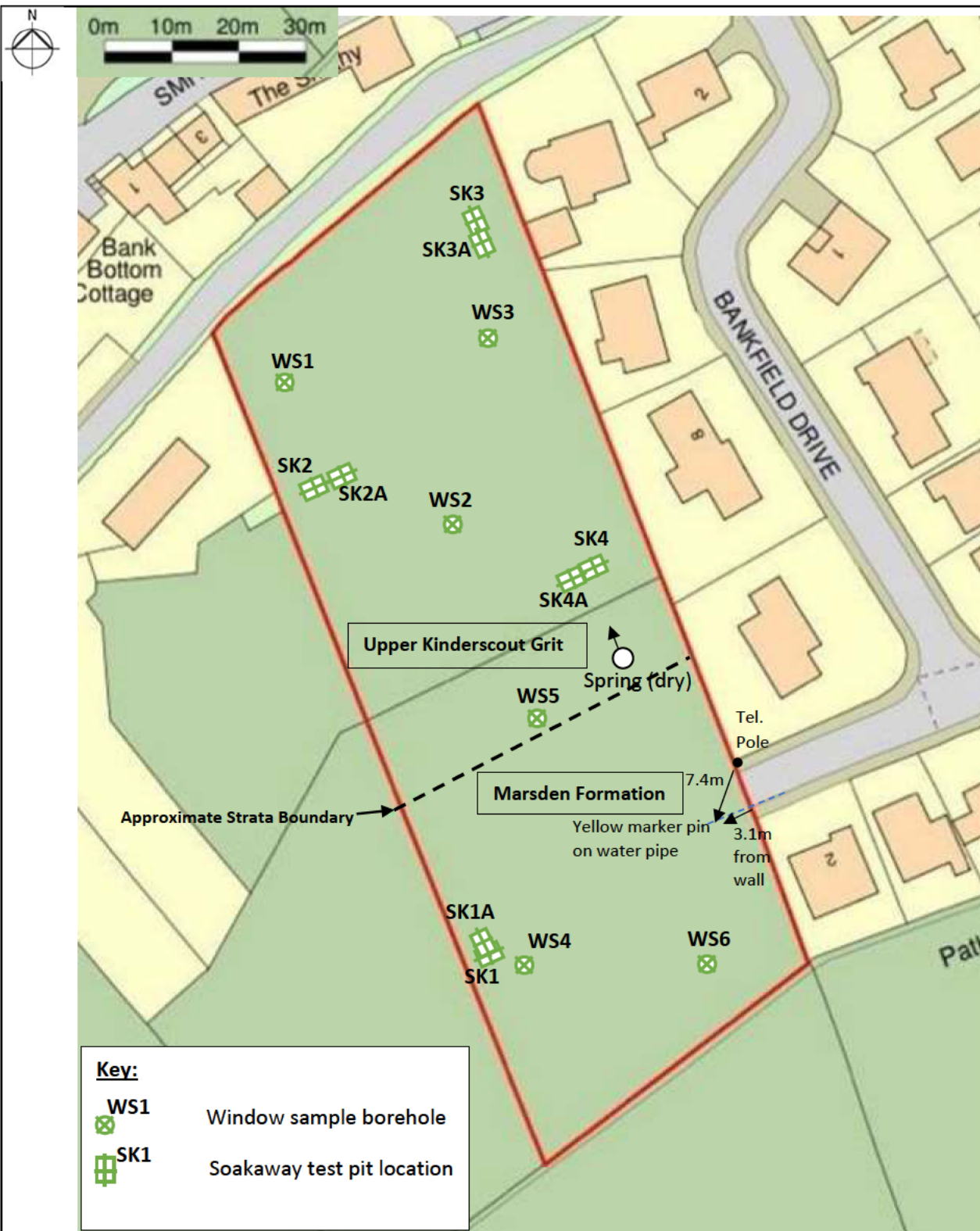


Appendix A

Drawings



GVR Geoservices Ltd 37-38 Market Street, Ferryhill, DL17 8JH e: grantvrichardson@gmail t: 07795 616 513	Job: G-22-009 Title: Land West of Bankfield Drive, Holmbridge, Holmfirth Client: Orion Homes	Scale: NTS Revision: 0 Drawing Number G-22-009-001
--	--	---

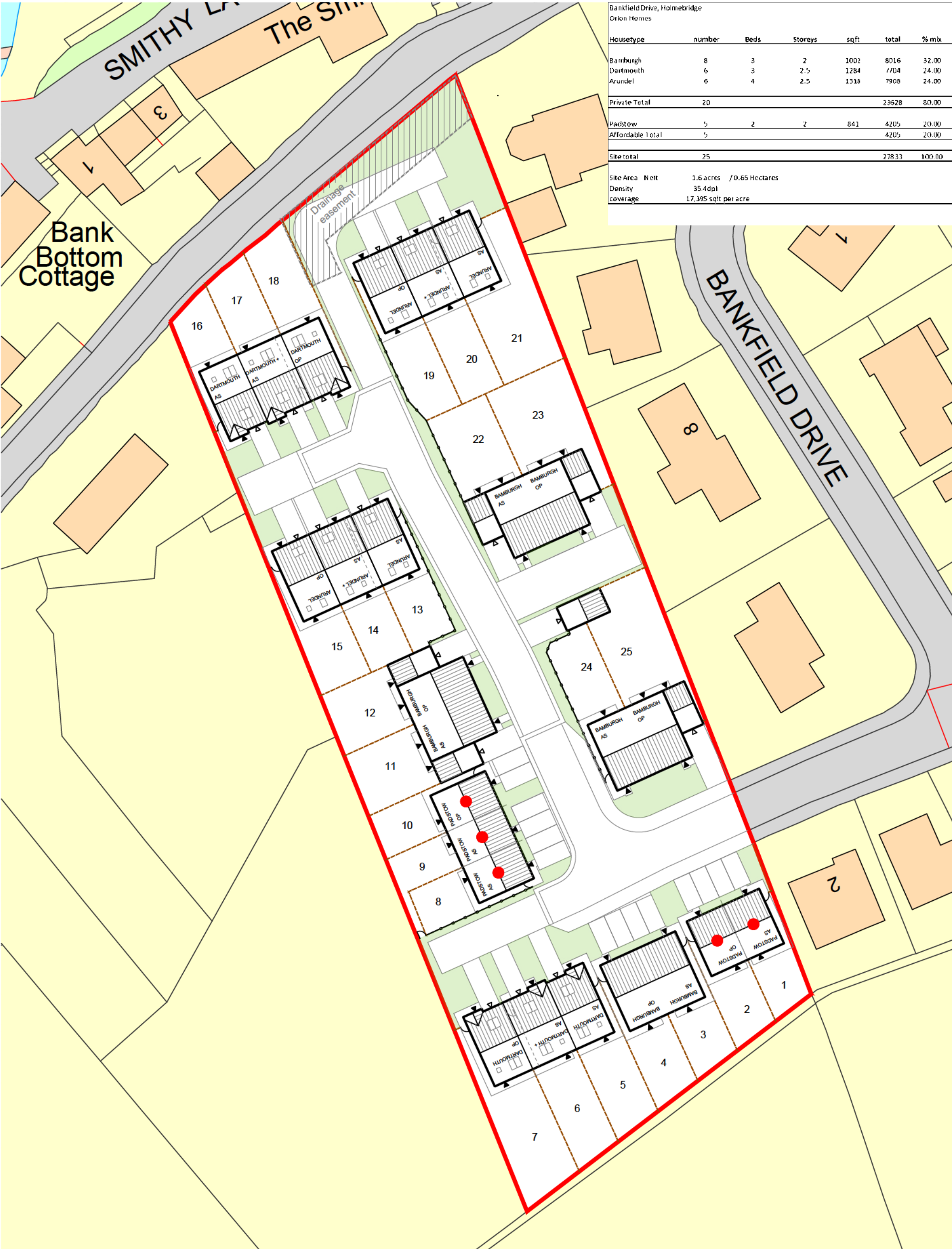


GVR Geoservices Ltd
 37-38 Market Street, Ferryhill, DL17 8JH
 e: grantvrichardson@gmail
 t: 07795 616 513

Job: Land West of Bankfield Drive, Holmbridge, Holmfirth
Title: Exploratory Hole Location Plan
Client: Orion Homes Ltd

Scale
 As shown
Revision
 2
Drawing Number
 G-22-009-002

Bankfield Drive, Holmebridge





Appendix B

Exploratory Hole Logs



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge		Drilling Equipment Track-mounted window sampler		WS1	
Job No. G-22-009		Engineer GVR		Date 15/03/2022	
Client Orion Homes Ltd		Ground Level (m) OD		Hole Depth (m) 1.45	

Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail
Depth (m)	No.					
0.05-0.3	D, J, V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.35		
0.65-0.75	D	2	'Medium dense' becoming very dense orange brown slightly silty fine to medium gravelly SAND with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	1.10		
CPT 1.0-1.45	N = 50/295mm		End of borehole 1.45m due to CPT refusal at 1.45m	1.5m 2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m		

Groundwater Observations No groundwater observed during drilling.	Observations Borehole backfilled with arisings on completion from 1.10-0.3m and bentonite pellets from 0.3 to GL.
---	---



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge		Drilling Equipment Track-mounted window sampler		WS2	
Job No. G-22-009		Engineer GVR		Date 15/03/2022	
Client Orion Homes Ltd		Ground Level (m) OD		Hole Depth (m) 1.45	

Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail
Depth (m)	No.					
0.05-0.25	D, J, V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.33		
		2	'Firm to stiff' pale yellow brown slightly sandy SILT with a little medium to coarse subangular to angular gravel of silty sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.5m 0.70		
0.9-1.0 CPT 1.0-1.45	D N = 50/290mm	3	'Medium dense' becoming very dense pale yellow brown mottled orange slightly clayey silty SAND with frequent angular to subangular gravel of sandstone lithorelics (highly weathered bedrock - Upper Kinderscout Grit).	1.0m 1.5m 1.45		
			End of borehole 1.45m due to CPT refusal at 1.45m	2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m		

Groundwater Observations No groundwater observed during drilling.	Observations Borehole backfilled with arisings on completion from 1.45-0.3m and bentonite pellets from 0.3 to GL.
---	---



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge		Drilling Equipment Track-mounted window sampler		WS3	
Job No. G-22-009		Engineer GVR		Date 15/03/2022	
Client Orion Homes Ltd		Ground Level (m) OD		Hole Depth (m) 1.3	

Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail
Depth (m)	No.					
0.05-0.3	D, J, V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.35		
0.5-0.7	D	2	'Medium dense' becoming very dense orange brown slightly silty fine to medium gravelly SAND with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.5m 1.0m		
CPT 1.0-1.45	N = 50/295mm	3	From 0.7m: with frequent cobbles of sandstone Medium strong pale yellow silty fine to coarse SANDSTONE with a matrix of sand in joints. (highly weathered bedrock - Upper Kinderscout Grit).	1.30		
			End of borehole 1.3m due to CPT refusal at 1.45m	1.5m 2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m		

Groundwater Observations No groundwater observed during drilling.	Observations Borehole backfilled with arisings on completion from 1.30-0.3m and bentonite pellets from 0.3 to GL.
---	---



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge		Drilling Equipment Track-mounted window sampler		WS4	
Job No. G-22-009		Engineer GVR		Date 15/03/2022	
Client Orion Homes Ltd		Ground Level (m) OD		Hole Depth (m) 4.0	

Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail
Depth (m)	No.					
0.05-0.25	D J V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.25		
HSV 0.60	38kPa	2	'Firm' pale yellow mottled orange silty slightly sandy CLAY (residual soil of weathered bedrock - Marsden Formation).	0.5m 0.65		
1.1-1.2 CPT 1.0-1.45	D N = 13	3	'Soft to firm' medium strength pale yellow mottled orange brown clayey slightly sandy SILT (residual soil of weathered bedrock - Marsden Formation). From 1.1m: 'firm' laminated	1.0m 1.5m 1.65		
		4	'Very stiff' dark grey brown indistinctly very thinly laminated CLAY with lithorelics of silty sandstone (residual soil of weathered bedrock - Marsden Formation)	2.0m 2.10		
CPT 2.0-2.45	N = 10	5	'Firm to stiff' medium becoming high strength dark grey very thinly laminated very silty CLAY with pale brown silt partings on laminae (residual soil of weathered bedrock - Marsden Formation).	2.5m 3.0m 3.5m 3.50		
		6	Extremely weak, pale grey mottled orange brown very thinly laminated very silty SHALE with brown iron-stained fissure surfaces (highly weathered bedrock - Marsden Formation).	4.0m 4.00		
CPT 4.0-4.45	N = 50/265mm		End of borehole 4.00m due to CPT refusal at 4.45m	4.5m 5.0m 5.5m 6.0m		

Groundwater Observations No groundwater observed during drilling.	Observations Borehole backfilled with arisings on completion from 4.0-0.3m and bentonite pellets from 0.3 to GL.
---	--



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge		Drilling Equipment Track-mounted window sampler		WS5	
Job No. G-22-009		Engineer GVR		Date 15/03/2022	
Client Orion Homes Ltd		Ground Level (m) OD		Hole Depth (m) 2.0	

Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail
Depth (m)	No.					
0.05-0.25	D J V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.25		
1.0-1.1 CPT 1.0-1.45	D N = 15	2	'Firm' medium strength pale yellow mottled orange clayey slightly sandy SILT with a little fine to coarse subangular to angular gravel of silty sandstone lithorelics (residual soil of weathered bedrock - Upper From 1.0m: 'firm to stiff'	0.5m 1.0m 1.45		
CPT 2.0-2.45	N = 50/210mm	3	Friable medium becoming very dense pale yellow grey mottled orange very silty clayey coarse SAND with a little fine to coarse angular to subangular gravel of sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit). End of borehole 2.0m due to CPT refusal at 2.45m	2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m		

Groundwater Observations No groundwater observed during drilling.	Observations Borehole backfilled with arisings on completion from 2.0-0.3m and bentonite pellets from 0.3 to GL.
---	--



WINDOW SAMPLE LOG

Job Name Land off Bankfield Drive, Holmbridge			Drilling Equipment Track-mounted window sampler			WS6		
Job No. G-22-009			Engineer GVR			Date 15/03/2022		
Client Orion Homes Ltd			Ground Level (m) OD			Hole Depth (m) 3.0		
Samples/Tests		Strata No.	Strata Description	Depth (m)	Soil	Well Detail		
Depth (m)	No.							
0.05-0.25	D J V	1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.25				
HSV 0.75 0.8-0.95 HSV 0.85 CPT 1.0-1.45	61kPa D 70kPa N=13	2	'Firm' medium strength pale yellow mottled orange clayey slightly sandy SILT (residual soil of weathered bedrock - Marsden Formation). From 1.4m: 'Firm to stiff', laminated	0.5m 1.0m 1.5m 2.0m				
CPT 2.0-2.45	N = 12	3	'Very stiff' dark grey with pale brown silt partings, very thinly laminated very silty CLAY (residual soil of weathered bedrock - Marsden Formation).	2.00 2.5m 2.65				
		4	Extremely weak, dark grey black very silty thinly laminated clayey SHALE with laminations of stiff clay and with brown iron-stained fissure surfaces (highly weathered bedrock - Marsden Formation). End of borehole 2.80m due to CPT refusal at 3.45m	3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m				
CPT 3.0-3.45	N = 50/290mm							
Groundwater Observations No groundwater observed during drilling.				Observations Borehole backfilled with arisings on completion from 3.0-0.3m and bentonite pellets from 0.3 to GL.				



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK1	
Job No. G-22-009		Engineer GVR			
Client Orion Homes Ltd		Ground Level (m) OD			
				Date 16/03/2022	

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.2	
		2	'Soft to firm' friable grey brown mottled orange very silty sandy CLAY (residual soil of weathered bedrock - Marsden Formation).		
		3	'Firm' red brown very silty laminated CLAY with pale brown silt on laminae (residual soil of weathered bedrock (residual soil of weathered bedrock - Marsden Formation).	1.40	
		4		1.60	
		5	'Firm to stiff' dark greyish black thinly laminated very silty CLAY with pale brown silt partings on laminae (residual soil of weathered bedrock - Marsden Formation).	1.90	
			Extremely weak pale brownish yellow very silty SHALE with a little gravel of siltstone and thick laminae of siltstone (highly weathered bedrock - Marsden Formation).	2.30	
			Base of Pit 2.3m		

Groundwater Observations All strata remained dry during excavation.	Pit Size (m) & Orientation 0.65W x 2.6L x 2.3D ENE-WSW	Stability/Observations 1. Stable in all strata during excavation.
---	---	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK2
Job No. G-22-009		Engineer GVR		
Client Orion Homes Ltd		Ground Level (m) OD		Date 16/03/2022

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.30	
		2	Pale yellow brown very silty slightly gravelly SAND with frequent cobbles of sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.90	
		3	Medium strong pale yellow very thinly to thinly bedded silty medium to coarse SANDSTONE (highly weathered bedrock - Upper Kinderscout Grit).	1.10	
			Base of Pit 1.1m (becoming difficult to excavate)		

Groundwater Observatio All strata remained dry during excavation.	Pit Size (m) & Orientation 0.65W x 2.6L x 0.9D ENE-WSW	Stability/Observations 1. Stable in all strata during excavation.
---	---	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK3	
Job No. G-22-009		Engineer GVR			
Client Orion Homes Ltd		Ground Level (m) OD		Date 16/03/2022	

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.30	
		2	Pale yellow brown very silty slightly gravelly SAND with frequent cobbles of sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.50	
		3		0.90	
			Medium strong pale yellow very thinly to thinly bedded silty medium to coarse SANDSTONE (highly weathered bedrock - Upper Kinderscout Grit).		
			Base of Pit 0.9m (becoming difficult to excavate)		

Groundwater Observatio All strata remained dry during excavation.	Pit Size (m) & Orientation 0.65W x 2.7L x 0.9D NNW-SSE	Stability/Observations 1. Stable in all strata during excavation.
---	---	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK4
Job No. G-22-009		Engineer GVR		
Client Orion Homes Ltd		Ground Level (m) OD		Date 16/03/2022

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.30	
		2	'Firm' yellow brown mottled orange very sandy silty CLAY (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.70	
		3	Pale yellow brown very silty slightly clayey slightly gravelly SAND with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	1.20	
		4	Medium strong pale yellow brown very thinly to thinly bedded silty fine to coarse SANDSTONE with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (highly weathered bedrock - Upper Kinderscout Grit).	1.50	
			Base of Pit 1.5m (becoming difficult to excavate)		

Groundwater Observations All strata remained dry during excavation.	Pit Size (m) & Orientation 0.65W x 2.9L x 1.5D ENE-WSW	Stability/Observations 1. Stable in all strata during excavation.
---	---	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment 13.5t tracked excavator		SK1A
Job No. G-22-009		Engineer GVR		
Client Orion Homes Ltd		Ground Level (m) OD 29/03/2022		

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with	0.25	
		2	'Soft to firm' friable grey brown mottled orange very silty sandy CLAY (residual soil of weathered bedrock - Marsden Formation).	0.60	
		3	'Firm to stiff' dark greyish black thinly laminated very silty CLAY with pale brown silt partings on laminae (residual soil of weathered bedrock - Marsden Formation).	2.30	
		4	Extremely weak pale grey very silty SHALE with a little gravel of siltstone and with cm-scale laminae of siltstone and (highly weathered bedrock - Marsden Formation). Base of Pit 2.5m	2.50	

Groundwater Observations All strata remained dry during excavation.	Pit Size (m) & Orientation 1.0W x 1.4L x 2.5D NW-SE	Stability/Observations 1. Stable in all strata during excavation.
---	--	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK2A
Job No. G-22-009		Engineer GVR		
Client Orion Homes Ltd		Ground Level (m) OD		
				Date 29/03/2022

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.25	
		2	Pale yellow brown very silty slightly gravelly SAND with frequent cobbles of sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.60	
		3	Medium strong pale yellow very thinly to thinly bedded silty medium to coarse SANDSTONE (highly weathered bedrock - Upper Kinderscout Grit).	1.50	
			Base of Pit 1.5m		

Groundwater Observatio All strata remained dry during excavation.	Pit Size (m) & Orientation 1.1W x 2.4L x 1.5D ENE-WSW	Stability/Observations 1. Stable in all strata during excavation.
---	--	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK3A		
Job No. G-22-009		Engineer GVR				Date 29/03/2022
Client Orion Homes Ltd		Ground Level (m) OD				

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.30	
		2	Pale yellow brown very silty slightly gravelly SAND with frequent cobbles of sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.70	
		3		0.90	
			Medium strong pale yellow very thinly to thinly bedded silty medium to coarse SANDSTONE (highly weathered bedrock - Upper Kinderscout Grit).		
			Base of Pit 0.9m		

Groundwater Observations All strata remained dry during excavation.	Pit Size (m) & Orientation 1.0W x 1.7L x 0.9D NNW-SSE	Stability/Observations 1. Stable in all strata during excavation.
---	--	---



TRIAL PIT LOG

Job Name Bankfield Drive, Holmbridge		Excavation Equipment JCB 3CX		SK4A
Job No. G-22-009		Engineer GVR		
Client Orion Homes Ltd		Ground Level (m) OD		Date 16/03/2022

Samples/Tests		Strata	Strata Description	Depth (m)	Strata
Depth (m)	No.	No.			
		1	Dark brown slightly clayey silty very sandy TOPSOIL with rootlets.	0.25	
		2	'Firm' yellow brown mottled orange very sandy silty CLAY (residual soil of weathered bedrock - Upper Kinderscout Grit).	0.60	
		3	Pale yellow brown very silty slightly clayey slightly gravelly SAND with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (residual soil of weathered bedrock - Upper Kinderscout Grit).	1.30	
		4	Medium strong pale yellow brown very thinly to thinly bedded silty fine to coarse SANDSTONE with fine to coarse subangular to angular gravel of medium to coarse sandstone lithorelics (highly weathered bedrock - Upper Kinderscout Grit).	1.50	
			Base of Pit 1.5m		

Groundwater Observations All strata remained dry during excavation.	Pit Size (m) & Orientation 0.9W x 1.1L x 1.5D ENE-WSW	Stability/Observations 1. Stable in all strata during excavation.
---	--	---



Appendix C

Geotechnical and Soakaway Test Results



Highways Laboratory
Bassington Drive • Cramlington • Northumberland • NE23 8AJ
Tel (01670) 737575 • Email highwayslaboratory@northumberland.gov.uk

CLASSIFICATION OF SOILS

Tests according to B.S. 1377 : 1990

Client: **GVR Geoservices Ltd**Engineer: **Grant Richardson**Project: **G-22-009 Bankfield Drive, Holmbridge**Location: **WS04 at 1.10m - 1.20m**Material Type: **Brown, grey, orange mottled silty CLAY with very occasional gravel.**Sample Specification: **Sampled by Site Staff/Client**Source: **Site**Date Sampled: **15/03/2022**Date Received: **18/03/2022**Sampled By: **Clients Staff**

	<u>Test Results</u>	<u>Specification</u>
--	---------------------	----------------------

Water Content (%):	19.4	BS EN ISO 17892-1;2014
--------------------	-------------	------------------------

The liquid and Plastic Limits are prepared in accordance with BS1377: Part 2: Clause 4.2.4 due to the nature of most materials in the surrounding area (Sandy CLAY with gravel cobbles and boulders)

Liquid Limit (%):	47	Part 2 Clause 4.4 (One point method)
-------------------	-----------	--------------------------------------

Plastic Limit (%):	24	Part 2 Clause 5.3
--------------------	-----------	-------------------

Plasticity Index (%):	23	Part 2 Clause 5.4
-----------------------	-----------	-------------------

Passing 425mic (%):	74	
---------------------	-----------	--

Soil Classification:	CI	
----------------------	-----------	--

Results reported herein relate only to the material supplied or sampled by the laboratory. This report shall not be reproduced except in full without prior written consent. Sampling certificate Uncertainty available on request where applicable. All testing carried out at NCC Laboratory

Remarks: **None**Certificate of sampling received: ☐

[✓] M. Newton, Laboratory Manager

[] P. Fletcher, Senior Technician

Start of Test Date: **18/03/2022**End of Test Date: **22/03/2022**Report Date: **22/03/2022**



Highways Laboratory
Bassington Drive • Cramlington • Northumberland • NE23 8AJ
Tel (01670) 737575 • Email highwayslaboratory@northumberland.gov.uk

CLASSIFICATION OF SOILS

Tests according to B.S. 1377 : 1990

Client: **GVR Geoservices Ltd**Engineer: **Grant Richardson**Project: **G-22-009 Bankfield Drive, Holmbridge**Location: **WS05 at 1.00m - 1.10m**Material Type: **Brown, orange very sandy CLAY with occasional gravel.**Sample Specification: **Sampled by Site Staff/Client**Source: **Site**Date Sampled: **15/03/2022**Date Received: **18/03/2022**Sampled By: **Clients Staff**

	<u>Test Results</u>	<u>Specification</u>
--	---------------------	----------------------

Water Content (%):	20.2	BS EN ISO 17892-1;2014
--------------------	-------------	------------------------

The liquid and Plastic Limits are prepared in accordance with BS1377: Part 2: Clause 4.2.4 due to the nature of most materials in the surrounding area (Sandy CLAY with gravel cobbles and boulders)

Liquid Limit (%):	32	Part 2 Clause 4.4 (One point method)
-------------------	-----------	--------------------------------------

Plastic Limit (%):	19	Part 2 Clause 5.3
--------------------	-----------	-------------------

Plasticity Index (%):	13	Part 2 Clause 5.4
-----------------------	-----------	-------------------

Passing 425mic (%):	74	
---------------------	-----------	--

Soil Classification:	CL	
----------------------	-----------	--

Results reported herein relate only to the material supplied or sampled by the laboratory. This report shall not be reproduced except in full without prior written consent. Sampling certificate Uncertainty available on request where applicable. All testing carried out at NCC Laboratory

Remarks: **None**Certificate of sampling received: ☐

[✓] M. Newton, Laboratory Manager

[] P. Fletcher, Senior Technician

Start of Test Date: **18/03/2022**End of Test Date: **22/03/2022**Report Date: **22/03/2022**



Highways Laboratory
Bassington Drive • Cramlington • Northumberland • NE23 8AJ
Tel (01670) 737575 • Email highwayslaboratory@northumberland.gov.uk

CLASSIFICATION OF SOILS

Tests according to B.S. 1377 : 1990

Client: **GVR Geoservices Ltd**Engineer: **Grant Richardson**Project: **G-22-009 Bankfield Drive, Holmbridge**Location: **WS06 at 0.80m - 0.95m**Material Type: **Brown, grey, orange mottled very Sandy CLAY with occasional gravel.****Sample Specification: Sampled by Site Staff/Client**Source: **Site**Date Sampled: **15/03/2022**Date Received: **18/03/2022**Sampled By: **Clients Staff**

	<u>Test Results</u>	<u>Specification</u>
--	---------------------	----------------------

Water Content (%):	27.3	BS EN ISO 17892-1;2014
--------------------	-------------	------------------------

The liquid and Plastic Limits are prepared in accordance with BS1377: Part 2: Clause 4.2.4 due to the nature of most materials in the surrounding area (Sandy CLAY with gravel cobbles and boulders)

Liquid Limit (%):	41	Part 2 Clause 4.4 (One point method)
-------------------	-----------	--------------------------------------

Plastic Limit (%):	25	Part 2 Clause 5.3
--------------------	-----------	-------------------

Plasticity Index (%):	16	Part 2 Clause 5.4
-----------------------	-----------	-------------------

Passing 425mic (%):	76	
---------------------	-----------	--

Soil Classification:	CI	
----------------------	-----------	--

Results reported herein relate only to the material supplied or sampled by the laboratory. This report shall not be reproduced except in full without prior written consent. Sampling certificate Uncertainty available on request where applicable. All testing carried out at NCC Laboratory

Remarks: **None**Certificate of sampling received: ☐

[✓] M. Newton, Laboratory Manager

[] P. Fletcher, Senior Technician

Start of Test Date: **18/03/2022**End of Test Date: **22/03/2022**Report Date: **22/03/2022**



ANALYTICAL TEST REPORT

Contract no: 107232

Contract name: GVR Bankfield Drive, Holmbridge, Eden Business Park, Penrith

Client reference: S1248

Clients name: Northumberland County Council

Clients address: Highways Laboratory
Bassington Drive
Cramlington
NE23 8AJ

Samples received: 18 March 2022

Analysis started: 18 March 2022

Analysis completed: 25 March 2022

Report issued: 25 March 2022

Key

U	UKAS accredited test
M	MCERTS & UKAS accredited test
\$	Test carried out by an approved subcontractor
I/S	Insufficient sample to carry out test
N/S	Sample not suitable for testing

Approved by: —
Megan Harris
Senior Reporting Administrator

Chemtech Environmental Limited

SAMPLE INFORMATION

MCERTS (Soils):

Soil descriptions are only intended to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions. MCERTS accreditation applies for sand, clay and loam/topsoil, or combinations of these whether these are derived from naturally occurring soils or from made ground, as long as these materials constitute the major part of the sample. Other materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

Lab ref	Sample id	Depth (m)	Sample description	Material removed	% Removed	% Moisture
107232-1	S1248/01	0.65-0.75	Sandy Clay with Gravel	-	-	13.9
107232-2	S1248/02	0.90-1.00	Sandy Clay with Gravel	-	-	10.5
107232-3	S1248/03	0.50-0.70	Sandy Clay with Gravel & Roots	-	-	19.0
107232-4	S1248/04	1.10-1.20	Sandy Loamy Clay w th Roots	-	-	18.4
107232-5	S1248/05	1.00-1.10	Sandy Loamy Clay w th Gravel	-	-	13.1
107232-6	S1248/06	0.80-0.95	Sandy Loamy Clay w th Gravel & Roots	-	-	18.2

Chemtech Environmental Limited

SOILS

Lab number			107232-1	107232-2	107232-3	107232-4	107232-5	107232-6
Sample id			S1248/01	S1248/02	S1248/03	S1248/04	S1248/05	S1248/06
Depth (m)			0.65-0.75	0.90-1.00	0.50-0.70	1.10-1.20	1.00-1.10	0.80-0.95
Date sampled			15/03/2022	15/03/2022	15/03/2022	15/03/2022	15/03/2022	15/03/2022
Test	Method	Units						
pH	CE004 ^M	un ts	7.3	7.0	6.8	4.7	6.2	5.8
Sulphate (2:1 water soluble)	CE061 ^U	mg/l SO ₄	<10	<10	115	<10	<10	<10

Chemtech Environmental Limited

METHOD DETAILS

METHOD	SOILS	METHOD SUMMARY	SAMPLE	STATUS	LOD	UNITS
CE004	pH	Based on BS 1377, pH Meter	As received	M	-	units
CE061	Sulphate (2:1 water soluble)	Aqueous extraction, ICP-OES	Dry	U	10	mg/l SO ₄

Chemtech Environmental Limited

DEVIATING SAMPLE INFORMATION

Comments

Sample deviation is determined in accordance with the UKAS note "Guidance on Deviating Samples" and based on reference standards and laboratory trials.

For samples identified as deviating, test result(s) may be compromised and may not be representative of the sample at the time of sampling.

Chemtech Environmental Ltd cannot be held responsible for the integrity of sample(s) received if Chemtech Environmental Ltd did not undertake the sampling. Such samples may be deviating.

Key

N	No (not deviating sample)
Y	Yes (deviating sample)
NSD	Sampling date not provided
NST	Sampling time not provided (waters only)
EHT	Sample exceeded holding time(s)
IC	Sample not received in appropriate containers
HP	Headspace present in sample container
NCF	Sample not chemically fixed (where appropriate)
OR	Other (specify)

Lab ref	Sample id	Depth (m)	Deviating	Tests (Reason for deviation)
107232-1	S1248/01	0.65-0.75	N	
107232-2	S1248/02	0.90-1.00	N	
107232-3	S1248/03	0.50-0.70	N	
107232-4	S1248/04	1.10-1.20	N	
107232-5	S1248/05	1.00-1.10	N	
107232-6	S1248/06	0.80-0.95	N	

Chemtech Environmental Limited

ADDITIONAL INFORMATION

Notes

Opinions and interpretations expressed herein are outside the UKAS accreditation scope.

Unless otherwise stated, Chemtech Environmental Ltd was not responsible for sampling.

All testing carried out at Unit 6 Parkhead, Stanley, DH9 7YB, except for subcontracted testing.

Methods, procedures and performance data are available on request.

Results reported herein relate only to the material supplied to the laboratory.

This report shall not be reproduced except in full, without prior written approval.

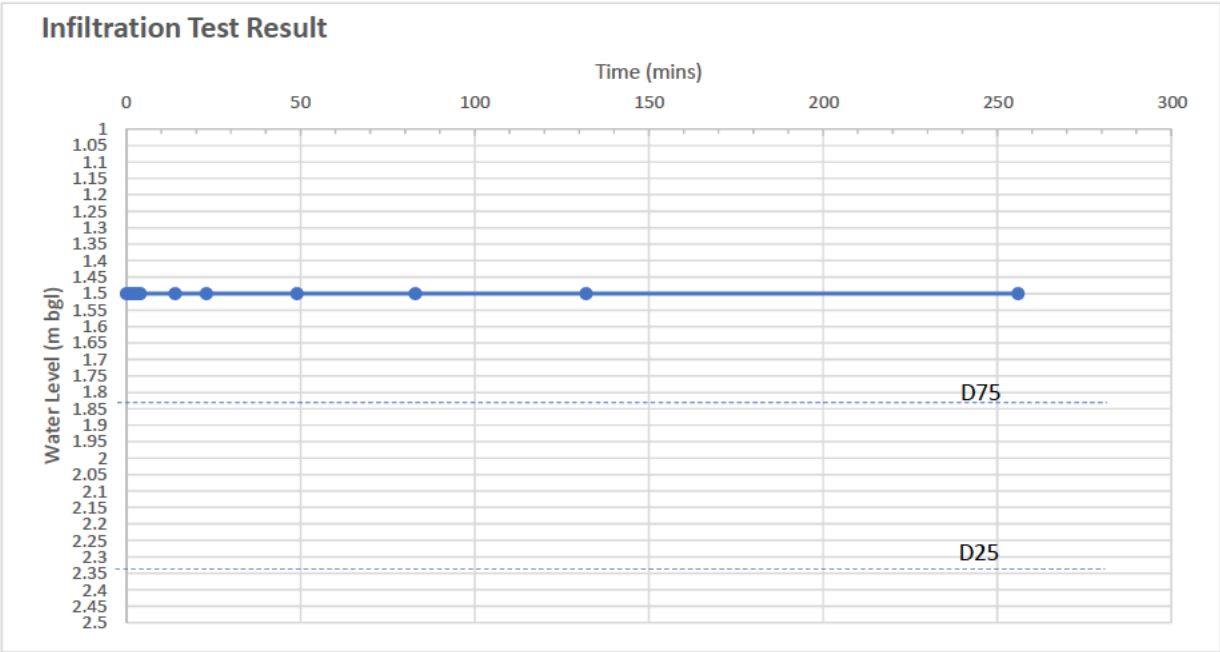
Samples will be disposed of 6 weeks from initial receipt unless otherwise instructed.

For soils and solids, all results are reported on a dry basis. Samples dried at no more than 30°C in a drying cabinet.

For soils and solids, analytical results are inclusive of stones, where applicable.

Trial Pit SK1A
Test No. 1
Depth of Pit (mbgl) 2.50
Water level at start of test (m bgl) 1.50
Depth of water column in pit at start (m) 1.00
Water level at end of test (m bgl) 1.50
Total Fall in water level (m) 0.00
D75 Level (m bgl) 1.75
D50 Level (m bgl) 2.00
D25 Level (m bgl) 2.25

Water Level (m				
Time (mins)	bgl)	Time(hr)		
0	1.5	09:35:00		
1	1.5	09:36:00	00:01:00	00:01:00
2	1.5	09:37:00	00:01:00	00:02:00
3	1.5	09:38:00	00:01:00	00:03:00
4	1.5	09:39:00	00:01:00	00:04:00
14	1.5	09:49:00	00:10:00	00:14:00
23	1.5	09:58:00	00:09:00	00:23:00
49	1.5	10:24:00	00:26:00	00:49:00
83	1.5	10:58:00	00:34:00	01:23:00
132	1.5	11:47:00	00:49:00	02:12:00
256	1.5	13:51:00	02:04:00	04:16:00





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK1A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 1

Trial Pit Dimensions (m)

Length, L_{TP} = 1.40

Width, W_{TP} = 1.00

Depth, D_{TP} = 2.50

Pit Voids %, PV = 100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Water Level (mbgl) at start of test, D_{TP} = 1.50

Depth of water in pit, m = 1.00

75% Effective Depth, D_{75} = 1.75

50% Effective Depth, D_{50} = 2.00

25% Effective Depth, D_{25} = 2.25

Time (mins) from 75% to 25% effective depth, T_L =

Time (s) from 75% to 25% effective depth, T_L = 0

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}

= $(L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$ = 0

Area (m^2) through which the above volume escapes between (D_{75} -25)

Area_{p50}

= Base Area + Sides Area (from D_{75} to D_{25})

= $(L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$

= 3.8

Soil Infiltration Rate, f =

$$\frac{V_{TP75-25}}{AP_{50} \times T_L} =$$

#DIV/0! m/s

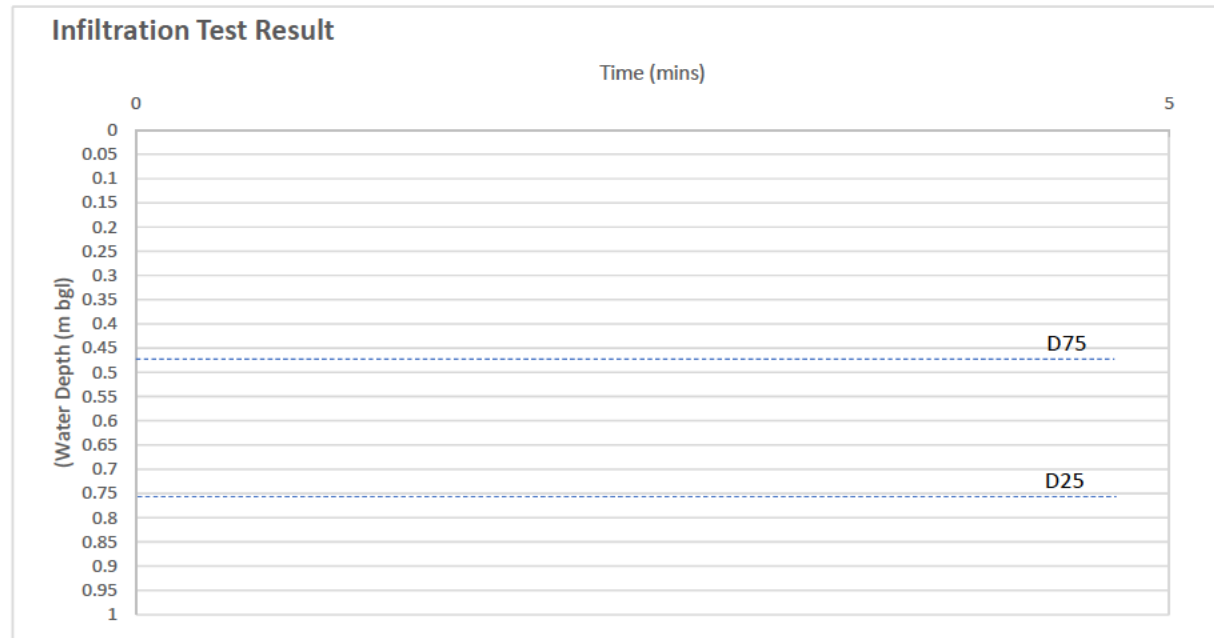
NON-COMPLIANT TEST RESULT: NO
INFILTRATION AFTER 4HRS 16MIN

Trial Pit	SK2A
Test No.	1
Depth of Pit (mbgl)	1.50
Water level at start of test (m bgl)	1.50
Depth of water column in pit at start (m)	0.00
Water level at end of test (m bgl)	1.50
Total Fall in water level (m)	0.00
D75 Level (m bgl)	1.50
D50 Level (m bgl)	1.50
D25 Level (m bgl)	1.50

	(Water Depth
Time (mins)	(m bgl)

Note

1. Water drained as quickly as pit could fill from a 2" dia. pipe
2. No readings possible





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK2A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 1

Base of Test Pit Dimensions (m)

Length, L_{TP}	=	1.40
Width, W_{TP}	=	1.10
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Notes

1. Water drained as quickly as pit could fill from a 2" dia. pipe
2. No readings possible

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.50
Depth of water in pit, m	=	0.00
75% Effective Depth, D_{75}	=	1.50
50% Effective Depth, D_{50}	=	1.50
25% Effective Depth, D_{25}	=	1.50

Time (mins) from 75% to 25% effective depth, T_L	=	7.50
Time (s) from 75% to 25% effective depth, T_L	=	450

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= ($L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV$)	1000

Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area_{P50}

= Base Area + Sides Area (from D_{75} to D_{25})

= ($L_{TP} \times W_{TP}$) + ($D_{75} - D_{25} \times L_{TP} \times 2$) + ($D_{75} - D_{25} \times W_{TP} \times 2$)

= 1.54

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{AP_{50} \times T_L}$	=	1.4E+00 m/s
---	--	---	-------------



SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK2A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 2

Base of Test Pit Dimensions (m)

Length, L_{TP}	=	1.40
Width, W_{TP}	=	1.10
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Notes

1. Water drained as quickly as pit could fill from a 2" dia. pipe
2. No readings possible

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.45
Depth of water in pit, m	=	0.05
75% Effective Depth, D_{75}	=	1.46
50% Effective Depth, D_{50}	=	1.48
25% Effective Depth, D_{25}	=	1.49

Time (mins) from 75% to 25% effective depth, T_L	=	8.50
Time (s) from 75% to 25% effective depth, T_L	=	510

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= ($L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV$)	1000

Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area A_{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= ($L_{TP} \times W_{TP}$) + ($D_{75} - D_{25} \times L_{TP} \times 2$) + ($D_{75} - D_{25} \times W_{TP} \times 2$)	
=	1.665

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{A_{P50} \times T_L}$	=	1.2E+00 m/s
---	--	---	-------------



SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK2A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 3

Base of Test Pit Dimensions (m)

Length, L_{TP}	=	1.40
Width, W_{TP}	=	1.10
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Notes

1. Water drained as quickly as pit could fill from a 2" dia. pipe
2. No readings possible

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.45
Depth of water in pit, m	=	0.05
75% Effective Depth, D_{75}	=	1.46
50% Effective Depth, D_{50}	=	1.48
25% Effective Depth, D_{25}	=	1.49

Time (mins) from 75% to 25% effective depth, T_L	=	9.00
Time (s) from 75% to 25% effective depth, T_L	=	540

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= ($L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV$)	1000

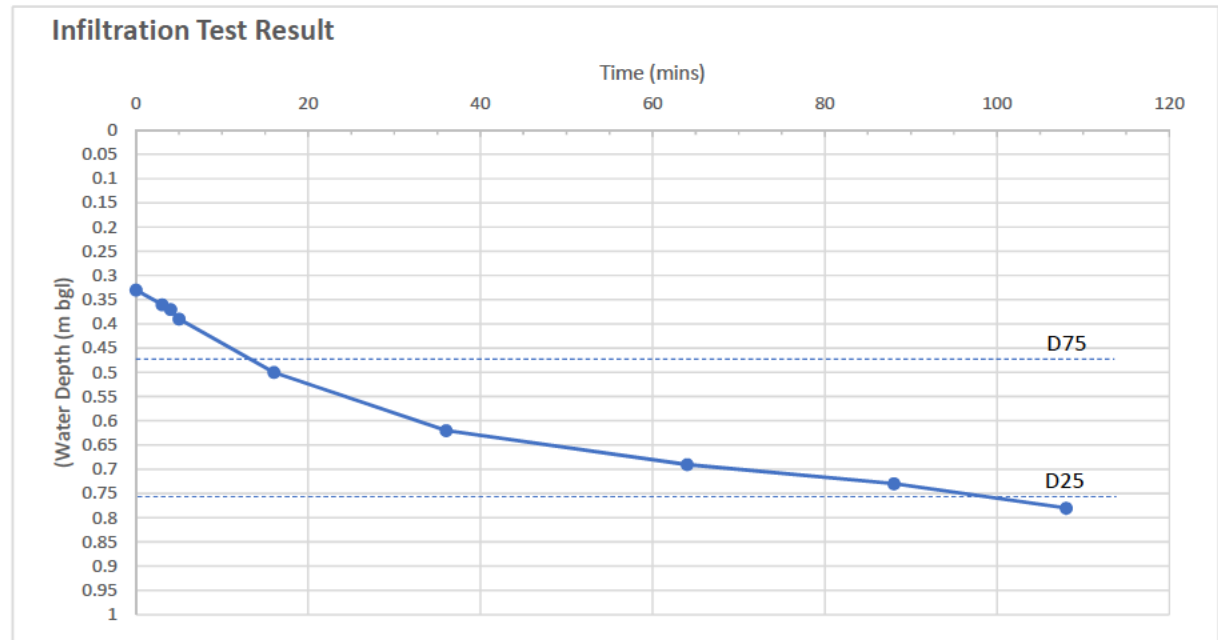
Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area A_{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= ($L_{TP} \times W_{TP}$) + ($D_{75} - D_{25} \times L_{TP} \times 2$) + ($D_{75} - D_{25} \times W_{TP} \times 2$)	
=	1.665

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{A_{P50} \times T_L} =$	1.1E+00 m/s
---	--	--------------------

Trial Pit SK3A
Test No. 1
Depth of Pit (mbgl) 0.90
Water level at start of test (m bgl) 0.33
 Depth of water column in pit at start (m) 0.57
 Water level at end of test (m bgl) 0.78
 Total Fall in water level (m) 0.45
 D75 Level (m bgl) 0.47
 D50 Level (m bgl) 0.62
 D25 Level (m bgl) 0.76

Time (mins)	(Water Depth (m bgl))
0	0.33
3	0.36
4	0.37
5	0.39
16	0.5
36	0.62
64	0.69
88	0.73
108	0.78





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK3A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 1

Trial Pit Dimensions (m)

Length, L_{TP}	=	1.70
Width, W_{TP}	=	1.00
Depth, D_{TP}	=	0.90
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Water Depth (mbgl) at Start of Test, D_{TP}	=	0.33
Depth of water in pit, m	=	0.57
75% Effective Depth, D_{75}	=	0.47
50% Effective Depth, D_{50}	=	0.62
25% Effective Depth, D_{25}	=	0.76

Time (mins) from 75% to 25% effective depth, T_L	=	85.00
Time (s) from 75% to 25% effective depth, T_L	=	5,100

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= $(L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$	0.4845

Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area _{p50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= $(L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$	
=	3.239

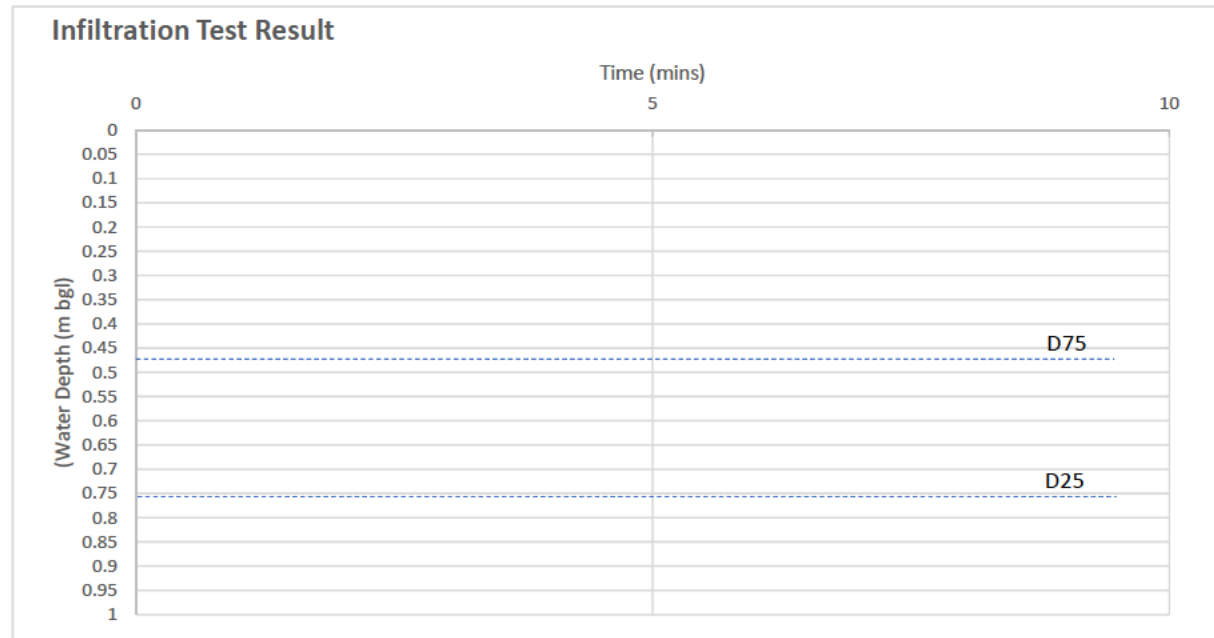
Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{AP_{50} \times T_L}$	=	2.9E-05 m/s
-------------------------------	--	---	-------------

Trial Pit	SK3A
Test No.	2
Depth of Pit (mbgl)	1.50
Water level at start of test (m bgl)	0.33
Depth of water column in pit at start (m)	1.17
Water level at end of test (m bgl)	0.78
Total Fall in water level (m)	0.45
D75 Level (m bgl)	0.62
D50 Level (m bgl)	0.92
D25 Level (m bgl)	1.21

	(Water Depth
Time (mins)	(m bgl)

Note

1. Deepened test pit to 1.5 after Test 1 to expose more bedrock
2. Water drained as quickly as pit could fill from a 2" dia. pipe
3. No readings possible





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK3A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 2

Trial Pit Dimensions (m)

Length, L_{TP}	=	1.20
Width, W_{TP}	=	1.10
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Note

1. Deepened test pit to 1.5 after Test 1 to expose more bedrock
2. Water drained as quickly as pit could fill from a 2" dia. pipe
3. No readings possible

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.43
Depth of water in pit, m	=	0.07
75% Effective Depth, D_{75}	=	1.45
50% Effective Depth, D_{50}	=	1.47
25% Effective Depth, D_{25}	=	1.48

Time (mins) from 75% to 25% effective depth, T_L	=	11.00
Time (s) from 75% to 25% effective depth, T_L	=	660

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= ($L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV$)	1000

Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area A_{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= ($L_{TP} \times W_{TP}$) + ($D_{75} - D_{25} \times L_{TP} \times 2$) + ($D_{75} - D_{25} \times W_{TP} \times 2$)	
=	1.481

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{A_{P50} \times T_L} =$	1.0E+00 m/s
effectively instantaneous soakage		



SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK3A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 3

Trial Pit Dimensions (m)

Length, L_{TP}	=	1.20
Width, W_{TP}	=	1.10
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open, PV = 100%. If pit stone filled, PV = 30%)

Notes

1. Deepened test pit to 1.5 after Test 1 to expose more bedrock
2. Water drained as quickly as pit could fill from a 2" dia. pipe
3. No readings possible

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.30
Depth of water in pit, m	=	0.20
75% Effective Depth, D_{75}	=	1.35
50% Effective Depth, D_{50}	=	1.40
25% Effective Depth, D_{25}	=	1.45

Time (mins) from 75% to 25% effective depth, T_L	=	10.25
Time (s) from 75% to 25% effective depth, T_L	=	615

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= ($L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV$)	1000

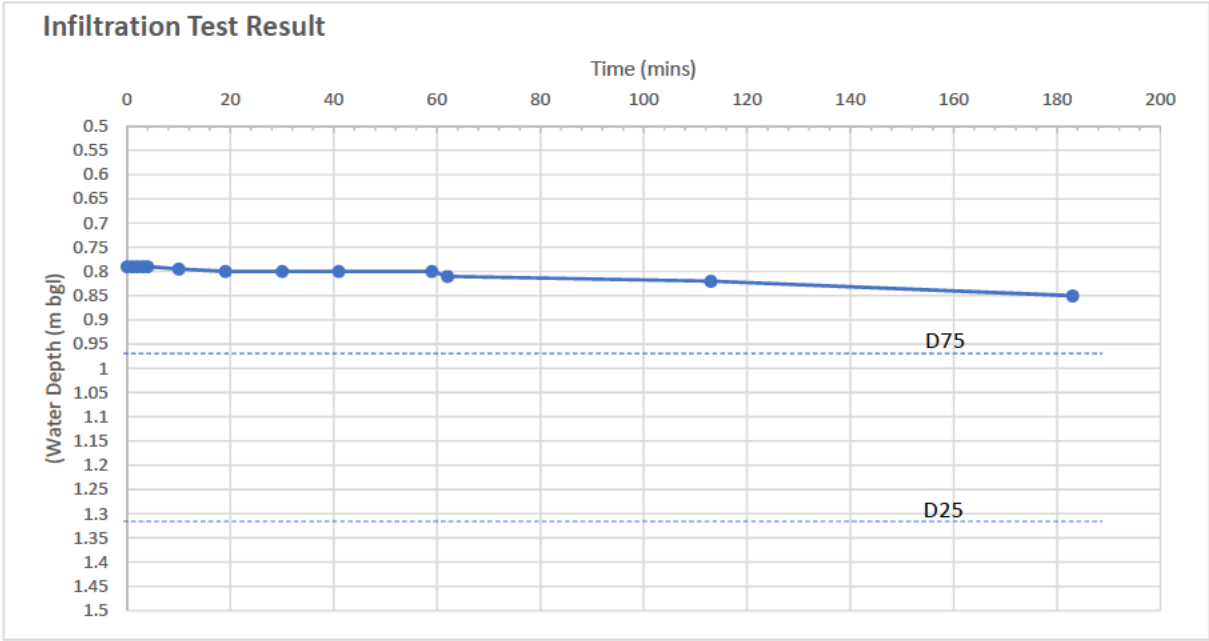
Area (m^2) through which the above volume escapes between (D_{75} - D_{25})

Area A_{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= ($L_{TP} \times W_{TP}$) + ($D_{75} - D_{25} \times L_{TP} \times 2$) + ($D_{75} - D_{25} \times W_{TP} \times 2$)	
=	1.78

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{A_{P50} \times T_L} =$	9.1E-01 m/s
effectively instantaneous soakage		

Trial Pit SK4A
Test No. 1
Depth of Pit (mbgl) 1.50
Water level at start of test (m bgl) 0.79
Depth of water column in pit at start (m) 0.71
Water level at end of test (m bgl) 0.85
Total Fall in water level (m) 0.06
D75 Level (m bgl) 0.97
D50 Level (m bgl) 1.15
D25 Level (m bgl) 1.32

(Water Depth				
Time (mins)	(m bgl)	Time(hr)		
0	0.79	09:52:00		
1	0.79	09:53:00	00:01:00	00:01:00
2	0.79	09:54:00	00:01:00	00:02:00
3	0.79	09:55:00	00:01:00	00:03:00
4	0.79	09:56:00	00:01:00	00:04:00
10	0.795	10:02:00	00:06:00	00:10:00
19	0.80	10:11:00	00:09:00	00:19:00
30	0.80	10:22:00	00:11:00	00:30:00
41	0.80	10:33:00	00:11:00	00:41:00
59	0.80	10:51:00	00:18:00	00:59:00
62	0.81	10:54:00	00:03:00	01:02:00
113	0.82	11:45:00	00:51:00	01:53:00
183	0.85	12:55:00	01:10:00	03:03:00





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK4A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 1

Trial Pit Dimensions (m)

Length, L_{TP}	=	1.10
Width, W_{TP}	=	0.90
Depth, D_{TP}	=	1.50
Pit Voids %, PV	=	100%

(Note - if pit open PV = 100%. If pit stone filled PV = 30%)

Water Depth (mbgl) at Start of Test, D_{TP}	=	0.79
Depth of water in pit, m	=	0.71
75% Effective Depth, D_{75}	=	0.97
50% Effective Depth, D_{50}	=	1.15
25% Effective Depth, D_{25}	=	1.32

Time (mins) from 75% to 25% effective depth, T_L	=	
Time (s) from 75% to 25% effective depth, T_L	=	0

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= $(L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$	0

Area (m^2) through which the above volume escapes between (D75-25)	
Area _{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= $(L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$	
=	2.41

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{AP_{50} \times T_L}$ =	#DIV/0! m/s
		NON-COMPLIANT TEST

Non-compliant Result

Water Depth (mbgl) at Start of Test, D_{TP}	=	0.79
Water Depth (mbgl) at end of test	=	0.85
Depth of Fall in Water Level during test, m	=	0.06

Time (mins) from start to end, T_n	=	183.00
Time (s) for observed fall in water level, T_L	=	10,980

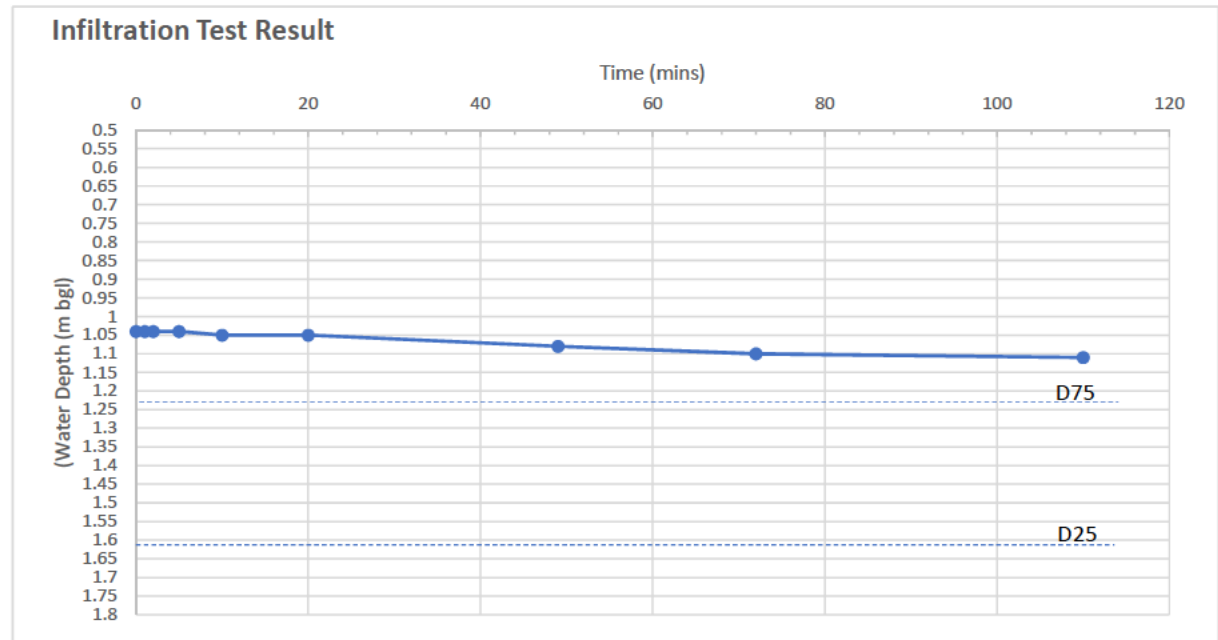
Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	
= $(L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$	0.0594

Area (m^2) through which the above volume escapes between (D75-25)	
Area _{P50}	
= Base Area + Sides Area (from D_{75} to D_{25})	
= $(L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$	
=	0.99

Soil Infiltration Rate, f =	$\frac{V_{TP75-25}}{AP_{50} \times T_L}$ =	5.5E-06 m/s
		NON-COMPLIANT TEST RESULT: AFTER 1HR 10MIN

Trial Pit SK4A
Test No. 2
Depth of Pit (mbgl) 1.80
Water level at start of test (m bgl) 1.04
 Depth of water column in pit at start (m) 0.76
 Water level at end of test (m bgl) 1.13
 Total Fall in water level (m) 0.09
 D75 Level (m bgl) 1.23
 D50 Level (m bgl) 1.42
 D25 Level (m bgl) 1.61

Time (mins)	(Water Depth (m bgl)	Time(hr)		
0	1.04	13:44:00		
1	1.04	13:45:00	00:01:00	00:01:00
2	1.04	13:46:00	00:01:00	00:02:00
5	1.04	13:49:00	00:03:00	00:05:00
10	1.05	13:54:00	00:05:00	00:10:00
20	1.05	14:04:00	00:10:00	00:20:00
49	1.08	14:33:00	00:29:00	00:49:00
72	1.10	14:56:00	00:23:00	01:12:00
110	1.11	15:34:00	00:38:00	01:50:00





SOAKAWAY TEST - BRE 365, 2016

Job Name Bankfield Drive, Holmbridge	Equipment 13.5t tracked excavator	
Job No. G-22-009	Engineer GVR	Test Pit SK4A
Client Orion Homes Ltd	Test Date 29/03/2022	Test No. 2

Trial Pit Dimensions (m)

Length, L_{TP}	=	1.10
Width, W_{TP}	=	0.90
Depth, D_{TP}	=	1.80
Pit Voids %, PV	=	100%

(Note - if pit open PV = 100%. If pit stone filled PV = 30%)

Note

1. Deepened test pit to 1.8m after Test 1 to expose more bedrock

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.04
Depth of water in pit, m	=	0.76
75% Effective Depth, D_{75}	=	1.23
50% Effective Depth, D_{50}	=	1.42
25% Effective Depth, D_{25}	=	1.61

Time (mins) from 75% to 25% effective depth, T_L	=	
Time (s) from 75% to 25% effective depth, T_L	=	0

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	=	
$= (L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$	=	0

Area (m^2) through which the above volume escapes between (D75-25)		
Area _{P50}		
= Base Area + Sides Area (from D_{75} to D_{25})		
$= (L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$	=	2.51

$$\text{Soil Infiltration Rate, } f = \frac{V_{TP75-25}}{AP_{50} \times T_L} = \frac{\#DIV/0!}{\text{NON-COMPLIANT TEST}}$$

Non-compliant Result

Water Depth (mbgl) at Start of Test, D_{TP}	=	1.04
Water Depth (mbgl) at end of test	=	1.13
Depth of Fall in Water Level during test, m	=	0.09

Time (mins) from start to end, T_n	=	110.00
Time (s) for observed fall in water level, T_L	=	6,600

Volume, $V_{TP75-25}$ (m^3) of infiltrated water during test between D_{75} and D_{25}	=	
$= (L_{TP} \times W_{TP} \times (D_{25} - D_{75}) \times PV)$	=	0.0891

Area (m^2) through which the above volume escapes between (D75-25)		
Area _{P50}		
= Base Area + Sides Area (from D_{75} to D_{25})		
$= (L_{TP} \times W_{TP}) + (D_{75} - D_{25} \times L_{TP} \times 2) + (D_{75} - D_{25} \times W_{TP} \times 2)$	=	0.99

$$\text{Soil Infiltration Rate, } f = \frac{V_{TP75-25}}{AP_{50} \times T_L} = \frac{1.4E-05}{\text{NON-COMPLIANT TEST RESULT: AFTER 1HR 10MIN}}$$



Appendix D

Chemical Test Results



Certificate of Analysis

Certificate Number 22-05453

Issued: 25-Mar-22

Client GVR Geoservices Limited
37-38 Market Street
Ferryhill
DL17 8JH

Our Reference 22-05453

Client Reference G-22-009

Order No G22-009/GVR/104

Contract Title Holmbridge

Description 6 Soil samples.

Date Received 21-Mar-22

Date Started 21-Mar-22

Date Completed 25-Mar-22

Test Procedures Identified by prefix DETSn (details on request).

Notes Opinions and interpretations are outside the laboratory's scope of ISO 17025 accreditation. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved By

A handwritten signature in blue ink, appearing to be "K. Bridgewood".

Kirk Bridgewood
General Manager



2139

Summary of Chemical Analysis

Soil Samples

Our Ref 22-05453
Client Ref G-22-009
Contract Title Holmbridge

Lab No	1985444	1985445	1985446	1985447	1985448	1985449
Sample ID	WS1	WS2	WS3	WS4	WS5	WS6
Depth	0.05-0.30	0.05-0.25	0.05-0.30	0.05-0.25	0.05-0.25	0.05-0.25
Other ID						
Sample Type	D	D	D	D	D	D
Sampling Date	15/03/2022	15/03/2022	15/03/2022	15/03/2022	15/03/2022	15/03/2022
Sampling Time	n/s	n/s	n/s	n/s	n/s	n/s

Test	Method	LOD	Units						
Metals									
Arsenic	DETSC 2301#	0.2	mg/kg	13	8.5	13	9.7	10	13
Cadmium	DETSC 2301#	0.1	mg/kg	0.3	0.2	0.3	0.3	0.3	0.2
Chromium	DETSC 2301#	0.15	mg/kg	17	20	14	17	19	19
Chromium, Hexavalent	DETSC 2204*	1	mg/kg	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper	DETSC 2301#	0.2	mg/kg	25	24	22	22	20	26
Lead	DETSC 2301#	0.3	mg/kg	53	340	58	93	55	86
Mercury	DETSC 2325#	0.05	mg/kg	0.14	0.08	0.12	0.09	0.15	0.14
Nickel	DETSC 2301#	1	mg/kg	16	13	9.0	9.6	10	10
Selenium	DETSC 2301#	0.5	mg/kg	0.6	< 0.5	0.7	< 0.5	0.7	< 0.5
Zinc	DETSC 2301#	1	mg/kg	73	72	67	72	61	55
Inorganics									
pH	DETSC 2008#		pH	6.0	6.0	5.5	5.4	5.6	5.2
Total Organic Carbon	DETSC 2084#	0.5	%	4.3	3.5	4.9	6.1	4.8	5.4
Sulphate Aqueous Extract as SO4	DETSC 2076#	10	mg/l	21	26	13	21	11	18
Sulphate as SO4, Total	DETSC 2321#	100	mg/kg	747	938	1010	1210	928	1030
PAHs									
Naphthalene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Acenaphthylene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Acenaphthene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Fluorene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Phenanthrene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Anthracene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Fluoranthene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pyrene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Benzo(a)anthracene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chrysene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Benzo(b)fluoranthene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Benzo(k)fluoranthene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Benzo(a)pyrene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Indeno(1,2,3-c,d)pyrene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dibenzo(a,h)anthracene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Benzo(g,h,i)perylene	DETSC 3301	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
PAH Total	DETSC 3301	1.6	mg/kg	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6

Summary of Asbestos Analysis

Soil Samples

Our Ref 22-05453

Client Ref G-22-009

Contract Title Holmbridge

Lab No	Sample ID	Material Type	Result	Comment*	Analyst
1985444	WS1 0.05-0.30	SOIL	NAD	none	Lee Kerridge
1985445	WS2 0.05-0.25	SOIL	NAD	none	Lee Kerridge
1985446	WS3 0.05-0.30	SOIL	NAD	none	Lee Kerridge
1985447	WS4 0.05-0.25	SOIL	NAD	none	Lee Kerridge
1985448	WS5 0.05-0.25	SOIL	NAD	none	Lee Kerridge
1985449	WS6 0.05-0.25	SOIL	NAD	none	Lee Kerridge

Crocidolite = Blue Asbestos, Amosite = Brown Asbestos, Chrysotile = White Asbestos. Anthophyllite, Actinolite and Tremolite are other forms of Asbestos. Samples are analysed by DETSC 1101 using polarised light microscopy in accordance with HSG248 and documented in-house methods. NAD = No Asbestos Detected. Where a sample is NAD, the result is based on analysis of at least 2 sub-samples and should be taken to mean 'no asbestos detected in sample'. Key: * - not included in laboratory scope of accreditation.

Information in Support of the Analytical Results

Our Ref 22-05453
Client Ref G-22-009
Contract Holmbridge

Containers Received & Deviating Samples

Lab No	Sample ID	Date Sampled	Containers Received	Hold time exceeded for tests	Inappropriate container for tests
1985444	WS1 0.05-0.30 SOIL	15/03/22	GJ 250ml GJ 60ml PT 1L		
1985445	WS2 0.05-0.25 SOIL	15/03/22	GJ 250ml GJ 60ml PT 1L		
1985446	WS3 0.05-0.30 SOIL	15/03/22	GJ 250ml, GJ 60ml, PT 1L		
1985447	WS4 0.05-0.25 SOIL	15/03/22	GJ 250ml, GJ 60ml, PT 1L		
1985448	WS5 0.05-0.25 SOIL	15/03/22	GJ 250ml, GJ 60ml, PT 1L		
1985449	WS6 0.05-0.25 SOIL	15/03/22	GJ 250ml GJ 60ml PT 1L		

Key: G-Glass P-Plastic J-Jar T-Tub

DETS cannot be held responsible for the integrity of samples received whereby the laboratory did not undertake the sampling. In this instance samples received may be deviating. Deviating Sample criteria are based on British and International standards and laboratory trials in conjunction with the UKAS note 'Guidance on Deviating Samples'. All samples received are listed above. However, those samples that have additional comments in relation to hold time, inappropriate containers etc are deviating due to the reasons stated. This means that the analysis is accredited where applicable, but results may be compromised due to sample deviations. If no sampled date (soils) or date+time (waters) has been supplied then samples are deviating. However, if you are able to supply a sampled date (and time for waters) this will prevent samples being reported as deviating where specific hold times are not exceeded and where the container supplied is suitable.

Soil Analysis Notes

Inorganic soil analysis was carried out on a dried sample, crushed to pass a 425µm sieve, in accordance with BS1377.

Organic soil analysis was carried out on an 'as received' sample. Organics results are corrected for moisture and expressed on a dry weight basis.

The Loss on Drying, used to express organics analysis on an air dried basis, is carried out at a temperature of 28°C +/-2°C.

Disposal

From the issue date of this test certificate, samples will be held for the following times prior to disposal :-

Soils - 1 month, Liquids - 2 weeks, Asbestos (test portion) - 6 months

End of Report



Appendix E

GVR Geo Generic Assessment Criteria

GAC Summary Table (Residential with homegrown produce end-use, SOM 6%)

Parameter	No. of samples tested	Range of results (mg/kg unless stated otherwise)	GAC (6.0% SOM)	No. of samples exceeding GAC
Metals, Metalloids, Non-metals				
Arsenic	3	8.5--13	37	0
Cadmium	3	0.2-0.3	11	0
Chromium III	3	14-20	910	0
Chromium VI	3	<1.0	6	0
Copper	3	20-26	2400	0
Lead	3	53-340	200	1
Mercury, Inorganic	3	0.08-0.15	40	0
Nickel	3	9.0-16	180	0
Selenium	3	<0.5-0.7	250	0
Zinc	3	55-73	3700	0
Inorganics				
pH, pH units	3	5.2-6.0	<2.5 - >9.5	0
Total Organic Carbon, % mass	3	4.3-6.1	>10	0
Sulphate Aqueous Extract as SO ₄ , mg/l	3	11-26	N/A	0
Total Sulphate as SO ₄	3	747-1210	2400	0
Polycyclic Aromatic Hydrocarbons				
Naphthalene	3	<0.1	2.3	0
Acenaphthylene	3	<0.1	170	0
Acenaphthene	3	<0.1	210	0
Fluorene	3	<0.1	170	0
Phenanthrene	3	<0.1	95	0
Anthracene	3	<0.1	2400	0
Fluoranthene	3	<0.1	280	0
Pyrene	3	<0.1	620	0
Benzo(a)anthracene	3	<0.1	7.2	0
Chrysene	3	<0.1	15	0
Benzo(b)fluoranthene	3	<0.1	2.6	0
Benzo(k)fluoranthene	3	<0.1	77	0
Benzo(a)pyrene	3	<0.1	2.2	0
Indeno(1,2,3-c,d)pyrene	3	<0.1	27	0
Dibenzo(a,h)anthracene	3	<0.1	0.24	0
Benzo(g,h,i)perylene	3	<0.1	320	0
Others				
Asbestos screen	3	NAD	Present	0