

Brookleigh

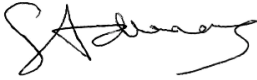
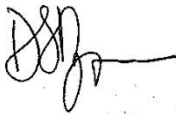
Phases 2, 3 and 4
Ground Investigation Report

Homes England

Project number: 60610807

November 2023

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The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The work described in this Report was undertaken between **July 2022** and **November 2023** and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances. AECOM disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to AECOM's attention after the date of the Report.

The exploratory holes carried out during the fieldwork, which investigate only a small volume of the ground in relation to the size of the site, can only provide a general indication of site conditions. The comments made and recommendations given in this Report are based on the ground conditions apparent at the site of the exploratory holes. There may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this Report.

The comments made on groundwater conditions are based on observations made during site work and the limited monitoring programme. It should be noted that groundwater levels might vary owing to seasonal or other effects.

The site reconnaissance consisted of a general external inspection of the site aimed at identifying any obvious signs of geotechnical hazards and potential sources of ground contamination affecting the site. An environmental compliance audit and/or detailed structural inspection of existing buildings were outside the project brief. Similarly, the site visit excluded detailed consideration of the ecological or archaeological aspects of the site, and if such are believed to be of potential significance then it is recommended that specialist advice is sought.

Any risks identified in this Report are perceived risks, based on the information reviewed during the study and therefore partially based on conjecture from available information. The investigation itself was designed generally to meet the objectives of an exploratory investigation, as defined by BS10175:2011 Investigation of Potentially Contaminated sites: Code of Practice (BSI). As an exploratory investigation, the results may not provide sufficient data to make detailed estimates of the quantities involved in any remediation work, if required.

The opinions expressed in this Report concerning any contamination found and the risks arising there from are based on current good practice assessment and comparison with available soil guideline values, AECOM generic assessment criteria and other guidance values.

It should be noted that the effects of ground and water borne contamination on the environment are constantly under review, and authoritative guidance values are potentially subject to change. The conclusions presented herein are based on the guidance values available at the time this Report was prepared, however, no liability by AECOM can be accepted for the retrospective effects of any changes or amendments to these values.

Reference to historical Ordnance Survey (OS) maps and/or data provides invaluable information regarding the land use history of a site. However, it should be noted that historical evidence will be incomplete for the period pre-dating the first edition and between the release of successive maps and/or data.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. AECOM specifically does not guarantee or warrant any estimate or projections contained in this Report.

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1. Executive Summary

AECOM Infrastructure & Environment UK Limited (AECOM) was commissioned to prepare a Ground Investigation Report (GIR) to inform the design of the proposed Brookleigh development scheme, in Burgess Hill, West Sussex (the "Site"). The reports aim is also to assist on the discharge of the associated contaminated land planning conditions and for this reason includes a Phase 2 Generic Qualitative Risk Assessment.

The GI followed a site walkover carried out by AECOM in 2022. The ground investigation (GI) was completed by Geotechnical Engineering Ltd (GEL) under the technical observation of AECOM between the 17 July and 22 August 2023. The GI comprised 24 rotary cored boreholes to up to 20m depth, 46 mechanically excavated trial pits and 18 dynamic sampling holes. Soakaway tests were undertaken in some trial pits and lightweight deflectometer testing was also undertaken. Geotechnical laboratory testing was undertaken to determine soil and rock properties

The ground investigation was not designed to provide complete coverage of the site for detailed design of the proposed development. The ground investigation was designed to allow an initial assessment of potential geotechnical and geoenvironmental risks associated with the proposed development. Further ground investigation may therefore be required.

The GI proved the geology to be fairly consistent across the site, with topsoil overlying Weald Clay Formation with varying weathering increments. Alluvium was found in one exploratory located in the southwest of the site. This is associated with the River Adur and it is likely that Alluvium will be present on the Site associated with this river and its tributaries. Made Ground was also found sporadically across the site in some locations associated with historical infilled ponds and farm buildings.

An interpretation of the ground conditions based on the field and laboratory results is presented. Ground models for the various areas of the site have been proposed and geotechnical parameters have been derived. The designer should select an appropriate ground profile and parameters for the structure being designed based on both exploratory hole descriptions and test data local to the structure. Further ground investigation may therefore be required to provide appropriate parameters for detailed design. The geotechnical risk register has been reviewed and updated accordingly.

The site is classified as a Geotechnical Category 2 in accordance with HD22/08 and BS EN 1997-1:2005.

Samples were analysed for a range of determinants and screened against human health Generic Assessment Criteria (GAC). The exceedances of the residential GAC are limited to five samples from three locations, RC01 0.13-0.23m bgl and 0.4-0.5m bgl, RC02 0.4-0.5m bgl, RC03 0.2-0.3m bgl and 0.4-0.5m bgl. Based on the current development plans, these locations are not due to be used for residential purposes as part of the proposed development and will fall within the area of the local road infrastructure network. No asbestos was recorded in 122 No. samples submitted for asbestos identification analysis nor was asbestos detected in the samples. For ground gas the site has been classified as Characteristic Situation 1: very low risk.

The soil leachate and groundwater samples from the site both recorded exceedances of GAC for PAH, metals and ammoniacal nitrogen. However, based on the current condition of groundwater at the site, groundwater does not appear to be significantly impacted upon by soil contamination and unacceptable risks to groundwater and surface water receptors are not considered to be present.

Overall, geoenvironmental risks to identified human health and controlled waters are considered to be low.

2. Introduction

2.1 Scope and Objectives

AECOM Limited (AECOM) was instructed by Homes England (the Client) to undertake a ground investigation (GI) at the proposed Brookleigh development (the site) to provide further assessment of the geotechnical and geo-environmental conditions of the site to inform geotechnical due diligence, planning, contaminated land assessment and remediation requirements for the development.

The Ground Investigation Report has been prepared in accordance with the requirements of CD 622 “Managing Geotechnical Risk”, BS EN 1993-2:2007 (Eurocode 7), BS 10175:2011+A2 2017 Investigation of Potentially Contaminated sites – Code of Practice and BS 5930 Code of Practice for Ground Investigations.

The objectives of the report are to:

- Present available information on ground and groundwater conditions of the site;
- Present ground profiles and geotechnical properties relevant to the geotechnical design of the proposed development;
- Present an initial assessment of potential geotechnical and geoenvironmental risks associated with the proposed development.

Intrusive works were undertaken by Geotechnical Engineering Ltd. (GEL) (CDM Principal Contractor) in July to August 2023 under the supervision of AECOM (CDM Principal Designer). A copy of the GEL Factual ground investigation report can be found in Appendix C.

The ground investigation was not designed to provide complete coverage of the site for detailed design of the proposed development. Further ground investigation may therefore be required.

2.2 Description of Project

2.2.1 Proposed Development

The project is located on predominantly greenfield land and some removal of existing buildings and infrastructure will be required as part of the site development. A Planning application will be submitted for the following, an indicative layout of which is presented in Appendix A;

- Up to 3,500 homes including 60 units of extra care accommodations (Class C3)
- Six traveller's pitches (Class C3)
- Up to 3880m² of combined Retail and food/drink (Class A1-A5) and small scale employment (Class B1)
- Up to 24,000 m² of dedicated employment spaces (Class B1 and B2)
- Up to 19,620 m² of Education facilities including three new schools (Class D1)
- Up to 1,600 m² of Healthcare facilities (Class D1)
- Up to 150 m² of Community Garden (Class D1)
- Up to 400 m² of Sports Facilities (Class D2)
- Associated road infrastructures, landscaping (including Sustainable Drainage Systems) and amenity space.

It is understood that full planning permission will be applied for; for engineering operations associated with remediation and infrastructures, the submitted parameter plans for approval are defined with identified limits of deviation to provide flexibility in how the detailed design of the development will be taken forward.

2.2.2 Site Description

The site is located north of Burgess Hill, West Sussex. The Brookleigh site encompasses an area of 178 hectares of land between Goddards Green Wastewater treatment plant at TQ 289206 and Isaac's Lane at TQ308208. Additional areas of ground investigation include a proposed attenuation pond (Pond 22) located 500m east of Isaac's Lane at TQ310209 and a proposed footbridge located 250m southeast of Isaac's Lane at TQ 310207. The results of these ground investigations are presented separately to this report.

The site area is understood to be under the ownership of Homes England since February 2018, with the exception of;

- land to the southeast in the vicinity of Burgess Hill Town Football Club and the Hub Employment area located to the west, and
- discrete areas including highways owned by the Mid and West Sussex District Councils.

In addition, current leaseholders are present within the site area at the time of the investigation.

The site currently comprises;

- Agricultural land;
- Pastoral land;
- Densely wooded areas;
- Recently constructed Freeks Farm and Maple Drive development (previous phase of part of the Burgess Hill development scheme); and
- Recreational land (Golf course).

For the purpose of design the site has been divided into several phases based on the land usage. The following areas are presented in Figure 2-1 and are the subject of the assessment within this report:

- 2A, 2A 255, 2B-231, 2C, 2C 352, 2D, 2D-227;
- 3A, 3A-299, 3B-386;
- 4A-260, 4B-254; and
- Western Park (WP).

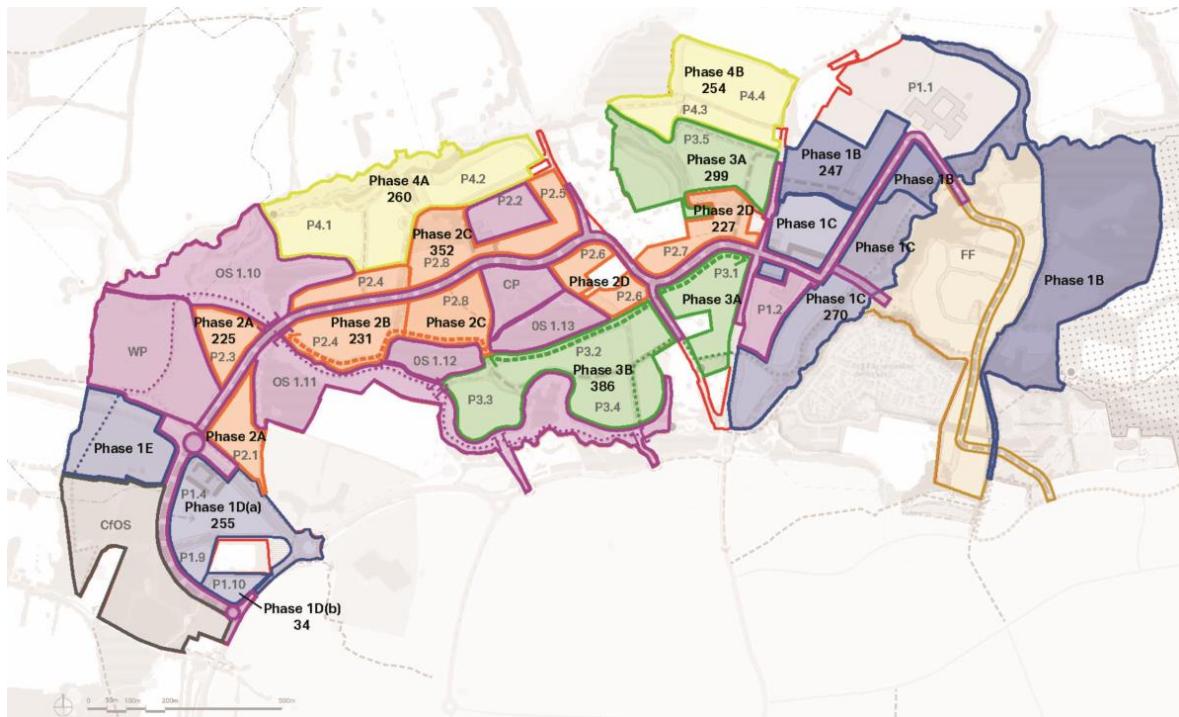


Figure 2-1 Northern Arc phasing and disposal plan revision 01 (January 2022)

2.3 Geotechnical Category of Project

Due to the nature of the proposed construction the site is considered to fall under Geotechnical Category 2 in accordance with BS EN 1997-1:2004 +A1:2013.

Projects in Geotechnical Category 2 include conventional types of geotechnical structures, earthworks and activities, with no exceptional geotechnical risks, unusual or difficult ground or loading conditions. For this category, geotechnical data analysis will normally be required to ensure that the fundamental requirements are satisfied. Geotechnical risks to the scheme are summarised in the Geotechnical Risk Register, included in Section 8 of this report. The register is a live document that should be developed and refined as the project progresses.

2.4 Contamination Risk of Project

The site is predominantly greenfield with no major sources of contamination identified in the preparatory works for the ground investigation. Geoenvironmental testing has been undertaken in order to characterise the site and to confirm there are no unexpected adverse conditions.

3. Existing Information

3.1 Topographical Map

Based on freely available LiDAR data (accessed November 2023) from the Environment Agency (EA), the Brookleigh site slopes towards the southwest from a maximum elevation of approximately 33m above Ordnance Datum (AOD), plateaus across the central area of the site at approximately 25m AOD, then gently slopes to approximately 20m AOD towards the River Adur. The elevations of exploratory locations undertaken in the GEL 2023 site-specific GI, discussed in Section 4 & 5 of this report, had an average elevation of 25.7mAOD. A maximum elevation of 33.3 mAOD was encountered within the west of the site at E:529237 N:120516 and a minimum elevation of 17.51mAOD in the south of the site at E:530012 N:120442.

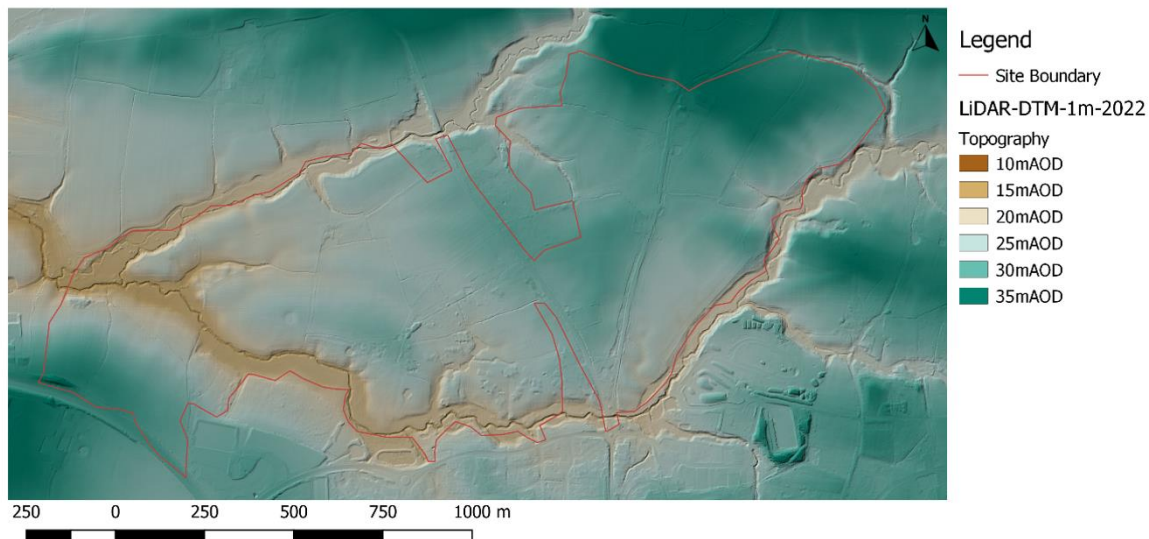


Figure 3-1 Topography of the site using Environment Agency 1m Lidar Data

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3.2 Geological Maps and Memoirs

The British Geological Survey (BGS) England and Wales Sheet 318/333 1:50,000 scale mapping for Brighton and Worthing (1996) indicates the majority of the site is directly underlain by Weald Clay Formation. This formation is characterised by dark grey mudstones with subordinate siltstones, sandstones, and includes clay ironstones. Clay ironstones are shown as elongated outcrops in the south-central part of the site in a west to east orientation.

The site is shown to locally be underlain by superficial Alluvial deposits associated with the tributaries of the Adur River and the Adur River, running northwest to northeast and following the approximate north and eastern site boundaries.

Table 3-1 summarises the published geology of the site as it was understood prior to the ground investigation.

Table 3-1 Summary of Published Geology

Geology	Age	Strata	Description	Anticipated Thickness *(m)
Superficial Deposits	Quaternary	Alluvium	Elongated outcrop associated with the River Adur East (i.e. the eastern end of the site only). Comprises clay, silt, sand and gravel, but it can also contain peat and basal gravel.	<10
Solid Geology	Hauterivian Age (KH) — Barremian Age (KB)	Weald Clay Formation	Directly underlies the majority of the site. Comprises mudstones with subordinate siltstones, limestones, sandstones, and clay ironstones.	120-275
	Hauterivian Age (KH)	Horsham Stone Member	Localised elongated outcrop running east-west, found east of Isaac's Lane. Comprises sandstone.	0-3 (up to 9m)

*Taken from Sheet 318/333 1:50,000 stratigraphic column

The bedrock at the site is shown to be the Weald Clay Formation of Hauterivian to Barremian age. This is described by the BGS as dark grey thinly bedded shales and mudstones with subordinate siltstones. There are also bands of fine to medium grained calcareous sandstone of the Horsham Stone Member and clay ironstones of the Weald Clay Formation mapped in a general east-west alignment across the site area.

There are no recorded Artificial deposits from British Geological Survey (BGS) mapping at 1:50,000 scale but due to land usage it is expected Made Ground will be present in the vicinity of farm buildings and within shallow ground beneath roadways.

East of Isaac's lane, the geology is affected by the Burgess Hill Fault with the near surface geology becoming the Horsham Stone Member together with Weald Clay Formation. Horsham Stone Member is characterised by sandstone.

The BGS maintains an archive of historical exploratory hole records throughout the UK. AECOM has searched the database and those which are considered to provide useful information on the ground profile at the site. A total of 8 no. records are located on the southern perimeter to the site on the A2300 as presented in Table 3-2.

Table 3-2 Summary of BGS Borehole Records

ID	Date	Distance to site	Grid Reference	Elevation (mAOD)	General description of log
TQ32SW24	1986	30m South	E:530210 N:120300	21.50	Topsoil 0-0.2m Made Ground 0.2-0.3m Mudstone 0.3-12.40m (Chiselling from 8.35m) Groundwater Strike 5.4m
TQ32SW25	1986	30m South	E:530210 N:120290	22.20	Topsoil 0-0.2m Mudstone 0.2-12.20m (Chiselling from 9.10m) Groundwater Strike 4.5m
TQ32SW26	1986	Onsite (Golf Course)	E:530560 N:120390	NA	Topsoil 0-0.2m Mudstone 0.2-5.0m Groundwater Strike 1.7m
TQ32SW27	1986	10m South	E:530450 N:120320	NA	Made Ground 0-0.35m Mudstone 0.35-3.0m
TQ22SWE52	1991	50m Southwest	E:529268 N:120368	31.21	Topsoil 0-0.5m Weathered Weald Clay 0.5-4.0m
TQ22SE51	1991	50m Southwest	E:529262 N:120422	32.91	Made Ground 0-0.5m Weathered Weald Clay 0.5-4.0m
TQ22SE50	1991	50m Southwest	E:529110 N:120400	34.40	Topsoil 0-0.3m Weathered Weald Clay 0.3-6.0m
TQ22SE49	1991	50m Southwest	E:529133 N:120467	33.24	Topsoil 0-0.3m Weathered Weald Clay 0.3-6.0m

3.3 Soils and Soil Chemistry

According to the Cranfield University Soilscape online viewer, the site lies on the boundary of Soilscape 8 in the North and Soilscape 20 in the South. The former is shown as being present on site and is described as being slightly acid loamy and clayey soils with impeded drainage. The latter is described as loamy and clayey floodplain soils with naturally high groundwater, associated with the River Adur.

Table 3-3 lists the anticipated background soil chemistry on site according to the UK Soil Observatory (UKSO).

Table 3-3 Anticipated Soil Chemistry

Element	Concentration (mg/kg)
Arsenic	17.29
Cadmium	0.34

Element	Concentration (mg/kg)
Chromium	16.67
Copper	24.40
Lead	61.26
Manganese	2600
Nickel	32.25
Zinc	99.31

3.4 Hydrology

Two tributaries of the River Adur are located within the site boundary, these are the Copyhold Stream which flows northeast to southwest across the northern boundary of the site into the River Adur and World's End stream which flows southeast to southwest along the southern boundary confluencing with the Copyhold Stream and River Adur. According to the Environment Agency's Online Main River viewer the River Adur has a statutory main river designation. A number of surface water ponds are located across the site, they are presented in the Brookleigh masterplan attached as Appendix A and located with Phase 3A, Phase 3B and Phase 2C land parcels. Other ponds may be present as discussed in section 3.6.

The EA flood risk maps for planning, an extract of which is shown below in Figure 3-2, illustrates that the site is predominately located within Flood Zone 1, however there are areas of land located in Zone 3 to the west associated with the River Adur. Land and property in Flood Zone 1 have a low probability of flooding which is defined as having a less than 1 in 1,000 annual probability of river flooding. Flood Zone 3 is defined as land with a 1 in 100 or greater annual probability of river flooding in any year.

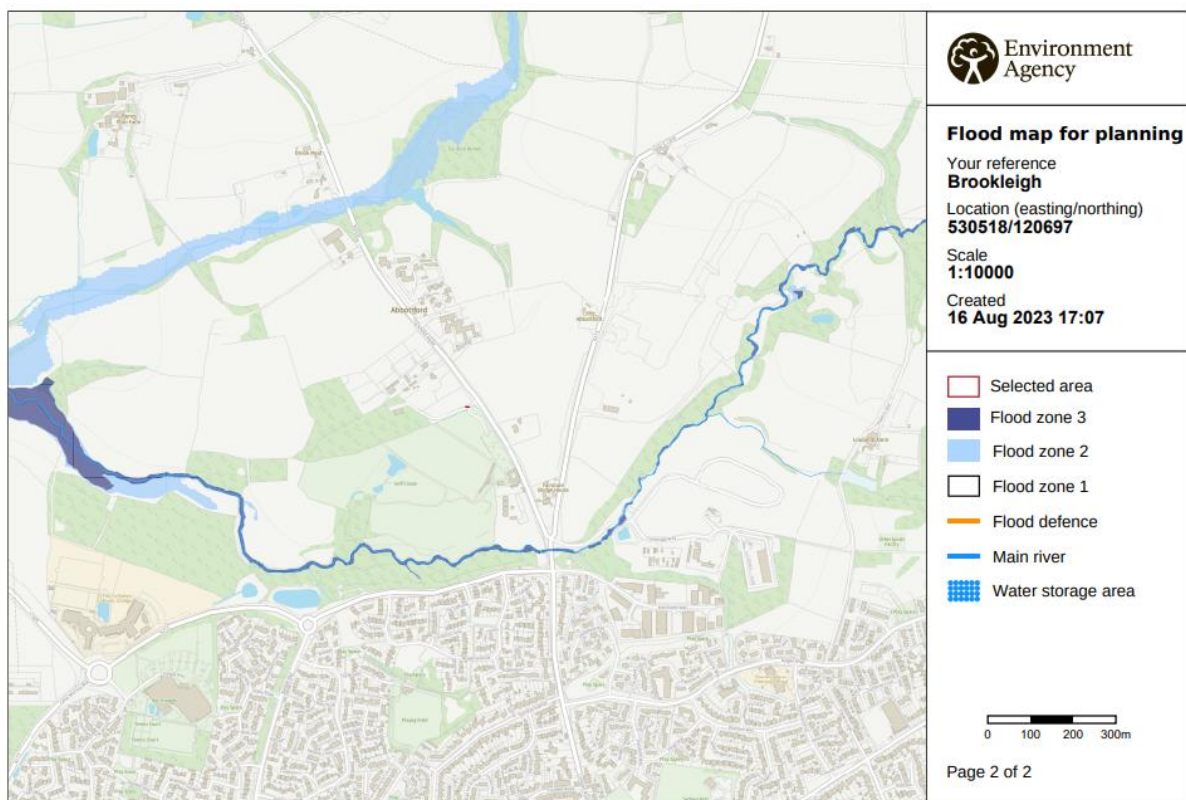


Figure 3-2 Flood Risk Planning Map of Brookleigh site

3.5 Hydrogeology

The Department for Environment, Food and Rural Affairs (DEFRA)'s MAGIC Map indicates that the Alluvium and bands of the Horsham Stone Member are classed as Secondary A Aquifers, whilst the underlying Weald Clay Formation is an unproductive strata. Secondary A Aquifers are described by the EA as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The EA's groundwater vulnerability map indicates that the area lies within an unproductive groundwater zone, classed as areas that have negligible significance for water supply or baseflow to rivers, lakes and wetlands. The bedrock has low permeability, naturally offering protection to any aquifers that may be present beneath.

The Alluvium is shown to have a low vulnerability risk which is characterised by low-leaching soils and/or the presence of low-permeability superficial deposits and offer the greatest protection to groundwater from pollution.

The bands of Horsham Stone Member are shown to be of high risk and can easily transmit pollution to groundwater. They are characterised by high-leaching soils and the absence of low-permeability superficial deposits.

According to the EA's groundwater data on MAGIC maps, the site is not located within a groundwater source protection zone (SPZ) nor are there any SPZ boundaries located within a 500m radius of the site.

3.6 Aerial Photographs and Historical Mapping

Historical Ordnance Survey (OS) maps of the site and the wider environs were provided in the Envirocheck (2018) Report (scales 1:2,500, 10:10,000 and 1:10,560). The historical Ordnance Survey (OS) maps obtained with the Envirocheck (2018) report date between 1879 and 1999.

Historical mapping has been reviewed to evaluate potential on and off-site past activities (up to a distance of 250m), that may have impacted the environmental condition and land quality of the site. A summary of the historical mapping review is presented in Table 3-5, Table 3-6 and Table 3-7. It should be noted that due to the size of the site, the Envirocheck mapping is split into 4 areas (A, B, C and D). On the smaller scale mapping these areas are split further as required and a plan showing this is included in Appendix D.

The historical mapping was obtained from Landmark previously when the red line boundary was slightly different to its current position. As such the following areas in the Envirocheck report have not been included in the below review of historical mapping: site A12, B9, B10, B14, C, C3, C4, D, D1 and D2.

The Envirocheck Areas correspond to the following phasing strategy of the Brookleigh site;

Table 3-4 Phasing Strategy Locations vs Envirocheck Report

Envirocheck Section	Phasing Diagram
A	Phase 3A 299 (west), Phase 227 (west), Phase 3A (west), Phase 4B (west) Phase 3B 386, Phase 2D, Phase 2C, Phase 2B 231, Phase 2C 252, Phase 4A 260, Phase 2A 225, Phase 2A, Western Park, Central Avenue (west)
A10	Western Park (south), Phase 2A 225
A11	Western Park (south), Phase 2 A
A14	Western Park (south), Phase 2A 225,
A15	Phase 4A 260, Phase 2B 351 (west), Phase 2C (west), Phase 3B (west)
A16	Phase 4A 260, Phase 2C, Phase 2C 352, Phase 2B 351 (east), Phase 2C (east), Phase 3B (east)
B	Phase 3A (east), Phase 2D 227 (east), Phase 3A 299 (east), Phase 1C 270 & Phase 1B 247 Phase
B13	4B (east), Central Avenue (east), Pond 22, GSH

Where dates are stated, these refer to the dates of maps on which the features are present, have changed use or are no longer annotated, and do not necessarily refer to the exact dates of existence of a particular feature. Development that may have occurred between map editions is recorded as occurring on the later published map, hence there are some limitations to the accuracy to the date of development unless supplementary evidence is available.

Table 3-5 Review of Historical Mapping at 1:10,000 and 1:10,560 scale

Area	Year (Scale)	Features on-site	Features off-site
A	1879 (1:10,560)	Land is shown to be occupied by open land likely used for agricultural purposes, footpaths shown crossing the site from the northwest to southeast. Floods Barn is located in the west of the site (529200, 120200). Tributaries (unnamed) of the River Adur are shown mapped on the site with a footbridge labelled in the north (529400,120600). A large portion of land located west of the present day Cuckfield Road is shown to be covered by woodland. The following ponds (unnamed) are shown at the site 529000,119600 (Phase 2B); 530000,120400 (Phase 3B); 52	Roads (unnamed) marked at the present day location of Cuckfield Road and A2300. The following ponds (unnamed) are shown within 250m of the site; 529600,120200; 529600,119600; 529200,119600; 528800,120200; 529000, 120600, 529400,120400 (Phase 1E), 529000,120200 (Phase 1E) , 529000,120200 (Phase 1E);
A	1899 (1:10,560)	Ponds are marked as a pit notation at; 529600,120600 (Phase 2C); 530000,120400 (Phase 4A). Unnamed but suspected farm buildings shown at 529600 120600 (Phase 2C). Footbridge no longer labelled.	No significant changes
A	1912 (1:10,560)	The following ponds (unnamed) identified on the 1879 mapping are still visible; 529400,120400 (Phase 3B); 530200,120400 (Phase 4A); 529600,120600 (Phase 2C).	The village of Abbotsford is shown to have multiple buildings assumed residential dwellings. Deans Farm Hospital of infectious diseases shown as present at the western site boundary. The Sewage works is shown to be partially constructed with Sewage Filters named.
A	1938-1952 (1:10,560)	No significant changes on site	Cuckfield Road named in present day location. Bridge hall Farm named at Cuckfield Road.
A	1962-1963 & 1969 (1:10,000)	Drain is shown present in the north of the site flowing towards Cuckfield Road. The area of woodland has reduced in the eastern part of the site surrounding Bridge Hall Farm. Electrical Pylons shown northeast to southwest crossing land phases Western Park , Phase E and Phase 1D(a)	Hospital now named Mid-Sussex Isolation Hospital. The sewage works are no longer shown. Works labelled west of Gatehouse Lane. Weir is mapped south of the site boundary at 53000, 120200
A	1974-1978 (1:10,000)	Footpath in the southwest of the site marked as a wider roadway running northeast to southwest from Gatehouse Lane.	A school is marked as present opposite Bridge Hall Farm at the Abbotsford Village.
A	1992-1994 (10,000)	West End Farm now mapped with multiple buildings at the previous location of Floods Barn. Electrical substation present on the unnamed roadway shown in the previous mapping at 529400,120000.	Further Works are shown at the northwest of the site area named Burgess Hill Sewage Works. Hospital renamed Goddards Green Unnamed works shown in 1962 mapping labelled Scrap depot.
.A	2000 (10,000)	Golf Driving range shown mapped west of Cuckfield Road. A273 and A2300 labelled with roundabout leading to Murray Way.	Significant development of residential housing to the southeast of the site boundary surrounding the Leisure Centre at

Area	Year (Scale)	Features on-site	Features off-site
		Additional bodies of water shown: 529200,120200 (Phase 1E); 529400,120400 (Phase 3B); 53000,120400 (Phase 4A); 529600,120400 (Phase 2C); 530200,120400 (Phase 3B).	the previously mapped Allotment Gardens.
A	2006 & 2018 (10,000)	No significant observations to change in land usage.	No significant observations to change in land usage.
B	1879,1899, 1912,1938-1950 (1:10,560)	The historical mapping indicated that the majority of the site has been occupied by fields and sporadic farm buildings. A pond is shown mapped to the north of the site area at 531000, 120600 (Phase 1C).	Sewage Farm is shown present and occupies the majority of the south of the site boundary.
B	1962-1963 ,1969, 1974-1978 (1:10,000)	Little to no change for the land usage. Further pond shown at: 531200,120620 (Phase 1C/Pond 22).	The Sewage Farm has shown to extend in size with additional tanks and beds visible. The London Road is shown to have many residential buildings along the route to central Burgess Hill Town.
B	1985, 1992 (1:10,000)	No significant observations to change in land usage, mapping is partially missing for maps in 1985, 1992.	No significant observations to change in land usage, mapping is partially missing for maps in 1985, 1992.
B	2000,2006,2018 (1:10,000)	The site area shows little to no development since its original mapping in 1899. The pond located at 531200,120620 (Phase 1C/Pond 22) is still present. Isaacs Lane has continued to be marked in its present day location.	No significant observations to change in land usage.

Table 3-6 Review of Historical Mapping at 1:2,500 scale

Area	Year (Scale)	Features on-site	Features off-site
B13	1875-1881 , 1897, 1910-1911 (1:2,500)	Unnamed River/stream is present along the south eastern boundary. Land usage is divided into agricultural fields. A small pond is shown east of Isaacs Lane.	Bridge Lodge is shown to be present. Sewage Farm named Burgess Hill UDC is shown to be present (1897) with development of filter beds (1910-1911).
B13	1937, 1956 (1:2,500)	No significant observations as to change in land usage on site	Sewage Farm is shown to contain pumping station, filter beds, sludge beds and multiple circular tanks. An unspecified pond/pit is present north of the works.
B13	1970, 1976, 1977-1989 (1:2,500)	River annotated with County Constituency and River Boundary, showing to flow west.	Further development of sludge beds and destructor south of the Sewage works (1976). Construction of the Isaacs Lane and Fairbridge Road Roundabout complete (1989).
B13	1979-1992, 1983 , 1985 , 1991 (1:2,500)	Mapping is partially incomplete for the site area. No significant observations to land change shown.	Mapping is partially incomplete for the site area. The Sewage works is shown to increase in size from 1979 to 1991 with additional access roads, tanks and filter beds.
B13	1994 (1:2,500)	The site is shown to remain largely unchanged from its initial mapping in 1875. The roads remain in their present day locations.	Two additional storm tanks are shown in the northeast of the Sewage works.
A10	1874-1881 , 1897, 1910-1911 (1:2,500)	Two unmarked ponds shown in the wooded area north of Gatehouse farm.	No significant observations.

Area	Year (Scale)	Features on-site	Features off-site
A10	1910-1911 , 1937 (1,2500)	Wooded area shown in the south, east of Gatehouse farm.	Sewage filters shown within 250m west of the boundary.
A10	1955-1958 , 1974-1975, 1978-1980 (1,2500)	No significant observations.	Sewage filters no longer shown. Hospital development additional wings. Timber yard named at the works west of the site.
A10	1982-1992 , 1994 , 1995, 1996 , (1,2500)	The most western pond is no longer shown on the mapping.	No significant observations.
A10	1874-1881 , 1897, 1910-1911 (1:2,500)	Two unnamed ponds shown in the wooded area north of Gatehouse farm.	No significant observations.
A11	1878-1881 , 1897, 1910-1911, 1937 (1:2,500)	No significant observations.	No significant observations.
A11	1878-1881 , 1897, 1910-1911, 1937 (1:2,500)	No significant observations.	No significant observations.
A11	1955-1957 (1:2,500)	Woodland shown in the south of the area. Electrical Pylons shown northeast to southwest.	Electrical Pylons continue off site towards the northeast.
A11	1974-1974 (1:2,500)	Electrical substation shown as present within site off Gatehouse Road.	No significant observations.
A11	1982-1992 , 1994 , 1995, 1996 (1:2,500)	Electrical pylons no longer shown present on map. Electrical substation has been moved north to the eastern part of the site area from unnamed access track on Gatehouse Road. Roundabout shown from 1996.	No significant observations.
A14	1874-1881, 1911, 1937, 1957-1958, 1974-1975 (1:2,500)	Floods barn shown in southeast of the site. Three Unnamed Ponds shown south of Floods Barn at Floods Barn and North of Floods Barn.	Two ponds shown present on site, one north off site and one located in the northeast of the site. Lower Barn is shown as one singular structure.
A14	1992, 1996 (1:2,500)	West End Farm shown present in the southwest of the site area with multiple structures and pond.	Burgess Hill Sewage Treatment works present northwest of the site.
A15	1881 (1:2,500)	The map shows an unmarked stream running northwest to southeast across the site. A copse of trees is shown potentially marking a pond or pitted area in the east. A small cluster of unmarked structures are present to the northeast, likely farming related shelters.	No significant observations.
A15	1897 (1:2,500)	The copse of trees is no longer marked on the map, the area is instead shown as a pit.	No significant observations.
A15	1937 , 1957 , 1975 (1:2,500)	The pit is no longer shown on the mapping (1937), one pond remains in the southwest of the site area within woodland.	Pond mapped in marsh land adjacent to northeaster boundary (1957).
A15	1992, 1994 , 1996 (1:2,500)	Electricity transmission line (ETL) marked on southwest of the mapping in an approximate north to south orientation. Woodland no longer shown as present (1994).	No significant observations.

Area	Year (Scale)	Features on-site	Features off-site
A16	1881, 1897, 1911 (1:2,500)	The land usage is shown to be two thirds agricultural land and one third (towards the north) of woodland. Two ponds or pits are located in the south. The river is shown flowing west at the site boundary.	Bridge Hall and Cuckfield road are marked present on the map.
A16	1937 (1:2,500)	No significant observations.	Bridge Hall Farm is shown as present on the mapping.
A16	1957, 1970, 1975-1976, 1983-1992(1:2,500)	Electrical pylons shown mapped northeast to southwest from Cuckfield road to end of the site boundary. Four pylons are marked within the site boundary.	Additional two electrical pylons shown as present 100m outside of the boundary.
A16	1970, 1975-1976, 1983-1992(1:2,500)	Access road (unmarked) running west from Bridge Hall Cuckfield road to the site centre is marked. Additional pond mapped west of the site.	Abbotsford village is shown to develop with associated residential housing (1957).
A16	1989-1992, 1992, 1994, 1996 (1:2,500)	No significant observations to change in land usage, mapping is partially missing for maps in 1992, 1994 and 1996.	The A273 is shown present (1989-1992). A "Gardening Pond" is present south of the site boundary (1996). Electrical substation present (1996).

Table 3-7 Review of Aerial Imagery

Area	Year (Scale)	Features on-site	Features off-site
B13	Aerial Imagery (1999)	The aerial imagery confirms the land usage to be largely of ploughed agricultural fields with some areas of vegetation surrounding the river.	The sewage works and sludge lagoons are shown in their full extent with previously unmapped cluster of light frame structures and storage area associated with "Gardening Services".
A16	Aerial Imagery (1999)	Mapping shows the golf course is present at the site, likely constructed from 1992 to 1999 based on no changes shown of the land area.	The previously noted "Gardening Pond" is shown as a wetlands nature area.
A15	Aerial Imagery (1999)	The aerial imagery shows the previously noted woodland is still present in the mapping areas, the detail looks to have been omitted from 1994 onwards. Electrical pylon is shown within the southwest of the site. The A2300 is shown constructed in the southwest of the site.	Surrounding land usage is shown to fields with little vegetation.
A14	Aerial Imagery 1999	Aerial imagery confirms that the pond location shown at West End farm is a partially infilled pit.	Access road to the sewage treatment works, and West End farm is shown.
A	Aerial Photography 1947 (1:10,560)	At the time of the photograph five fields are shown to be ploughed, four to be covered by woodland. The pond areas are not visible as covered by trees.	No significant observations.
A11	Aerial Imagery 1999 - Present	The aerial imagery confirms the observations of the mapping. The electrical substation, A273 and A2300 are labelled with a roundabout leading to Murray Way.	Residential housing development confirmed as present across the A273 and A2300.

3.7 Record of Mineral Deposits

According to the Envirocheck Report presented in Appendix D there is no history of coal mining and the area is indicated as an area not affected by coal mining. It is also indicated that there are no known mineral reserves in the area and that the risk of non-coal mining is classed as highly unlikely.

Suspected backfilled clay pits or ponds have been shown on historical mapping within the original extent of the Envirocheck officially recorded Clay pits have now been undertaken in previous phases of ground investigation. The locations of infilled suspected ponds have been targeted in the ground investigation locations for confirmation.

3.8 Land Use and Soil Survey Information

A review of available historical mapping indicates that the site and the surrounding land have been undeveloped fields with associated sporadic farm buildings since the late 1870's. Changes of land usage including filling of ponds, agricultural farming and redevelopment of farm buildings, (including yards where fuel and agricultural materials may have been stored) have been recorded since 1938. The contamination sources are likely to be associated with the Land Usage are discussed in Section 8.

3.9 Existing Ground Investigations

There are no known previous ground investigation works undertaken across the site area. However, there are recent phases of investigation undertaken for the purpose of the Northern Arc development located east of the site.

- WYG "Land off Maple Drive, Burgess Hill Geo-Environmental Factual & Interpretative Report A101197", dated October 2017
- Structural Soils "Maple Drive Link Road Factual Report on Ground Investigation 563139-1 (02)", dated August 2019
- Structural Soils "HE Northern Arc, Burgess Hill- Freeks Farm Ground Investigation 562943-Freeks Farm", dated July 2019
- AECOM Ground Investigation Report "Northern Arc- Burgess Hill- Eastern Bridge Link Road including A273 Isaac's Lane Junction and Bridge to Freeks Farm", dated September 2019
- AECOM Ground Investigation Report "Northern Arc- Freeks Farm & Maple Drive", dated September 2019

3.10 Unexploded Ordnance

A pre-desktop study assessment (PDSA) has been undertaken by Zetica for the site and noted that several Anti-Tank (AT) obstacles were established on the site. No readily available records were identified to indicate that the site was bombed however Burgess Hill Urban District (UD) officially recorded 20 No. High explosive bombs (HE) with a bombing density of 9.9 bomb per 405 hectares.

Risk Mapping for the site is shown to be low with an anticipated bomb density of less than 15 per 100 acres. The PDSA and Risk Mapping for the site can be found in Appendix E. The Zetica PDSA recommend that a detailed desk study, whilst always prudent, is not considered essential in this instance.

4. Field and Laboratory Studies

4.1 Walkover Survey

A walkover survey was carried out by AECOM prior to the ground investigation works commencing in May 2023. During this visit the site was assessed for access to the investigation locations and to observe the extents of identified constraints during the planning of intrusive works where present. Constraints identified on site during the walkover are listed in Table 4-1.

Table 4-1 Identified constraints

Constraint	Affected Area	Influence on Ground Investigation
Access	All parcels of land	The land usage of active agricultural fields at the site with the planned intrusive investigation to be undertaken during the season of growing prior to harvest requires minimal vehicle traffic through operational fields to avoid damage to any crops/vegetation on the fields, routes predefined and agreed with the land owner prior to works being undertaken. A weak footbridge was identified as a point of access for the ground investigation. A weight limit of 5 tonnes was applied to the bridge and as such machine types to cross were restricted. No access allowed via farm entrances and tracks from the north of the site.
Ecology	All parcels of land	Significant ecological constraints have been identified ahead of the planning of the ground investigation, standoff distances and alterations to the ground investigation programme based on the following flora and fauna identified on site; ancient woodland, reptile population, dormice, badgers, and bats. Restrictions adjacent to water bodies, longstanding farm buildings, densely vegetated areas. Compliance with the relevant authorities undertaken by the GI contractor during the works.
Site Users	Phase 3B, Phase 2	Restriction to working hours for accessing locations where livestock are required to be moved prior to works being undertaken and accessing locations that are located within the golf course.
Land Permission	Phase 3B	Intrusive locations are located within a golf course, on site movement of locations based on the ground conditions at the location to limit disturbance and damage. Access and locations confirmed with the Golf Course management prior to works being undertaken, restriction to working hours and additional time to programme for reinstatement and containment of flush and spoil.

4.2 Ground Investigation and Fieldwork

4.2.1 Description of Fieldwork

The aim of the GI was to undertake exploratory holes distributed across the site area for the purpose of providing future developers at each land parcel sufficient data to understand ground related risks. The GI was undertaken to characterise the ground profile and to determine geotechnical parameters and likely behaviours, the GI also considered geo-environmental data to assess the risk of contamination at the site and feasibility of material re-use.

The GI was undertaken by GEL between 17th July to 22nd August 2023 with AECOM carrying out full time technical supervision. Soil and Rock descriptions were carried out in accordance with BS5930:2015+A1:2020.

The GI works for the entire site (Phases 2, 3, and 4, Central Avenue, Western Park, Green Super Highway and Pond 22) consisted of the following:

- 24 Rotary Cored Boreholes to a depth of up to 20.00m bgl
- 18 Dynamic Sample Boreholes to a depth of up to 3.60m bgl
- 46 Machine Dug Trial Pits to a depth of up to 3.00m bgl; and
- 3 Road Cores to a depth of up to 1.20m bgl

In-situ testing comprised of:

- 17 Soakaway Infiltration tests within specified trial pits;
- 2 Falling head permeability tests
- 46 Lightweight deflectometers adjacent to trial pit locations;
- 3 Mackintosh probes with hand auger follow on to depths of up to 3.60m bgl
- 16 Dynamic Probes adjacent to dynamic sample boreholes where refusal occurred shallower than proposed depths;
- Hand vane, hand penetrometer strength testing at all exploratory hole locations;
- Standard Penetration Testing (SPT) at all borehole locations; and
- Photo Ionisation Detector (PID) screening at all exploratory locations.

The results of the GI can be found in the factual report in Appendix C.

It should be noted that on-site changes to the proposed works were undertaken due to identified constraints. The following comments on changes to proposed locations are noted in Table 4-2, and final locations can be viewed on the site location plans in Appendix B.

Table 4-2 Alterations to scope

Original Scope	Rationale
BH04	Moved to accommodate rig set up due to ground conditions
BH07	GPR identified an unknown trace near Gas Main – location moved
BH08	Moved to accommodate rig set up due to ground conditions
BH10	Moved due to ecological constraints
BH11	Moved due to ecological constraints
BH13	Moved due to site users at the golf course
BH14	Moved due to site users at the golf course
BH18	GPR identified Gas Main within stand off distance – location moved
BH21	Moved due to ecological constraints
BH23	Moved due to ecological constraints
BH24	Moved and changed due to ecological constraints located in ancient woodland to Hand Auger with Mackintosh Probe depth to 3.6m
BH25	Moved and changed due to ecological constraints located in ancient woodland to Hand Auger with Mackintosh Probe depth to 2.1m
BH26	Moved to accommodate rig set up due to ground conditions
BH27	Moved due to ecological constraints
TP02	Move away from land boundary fence
TP06	Terminated shallower due to smaller machine due to access
TP08	Terminated shallower due to smaller machine due to access
TP09	Terminated shallower due to smaller machine due to access
TP10	Terminated shallower due to smaller machine due to access
TP11	Terminated shallower due to smaller machine due to access
TP12	Terminated shallower due to smaller machine due to access
TP13	Moved due to ecological constraints, Terminated shallower due to smaller machine due to access
TP14	Terminated shallower due to smaller machine due to access
TP15	Terminated shallower due to smaller machine due to access
TP16	GPR identified Gas Main within stand off distance, Terminated shallower due to smaller machine due to access
TP17	Moved due to ecological constraints, Terminated shallower due to smaller machine due to access
TP18	GPR identified Gas Main within stand off distance, Terminated shallower due to smaller machine due to access
TP19	Terminated shallower due to smaller machine due to access
TP20	Moved due to ecological constraints, Terminated shallower due to smaller machine due to access

Original Scope	Rationale
TP21	Moved due to ecological constraints, Terminated shallower due to smaller machine due to access
TP22	Moved due to site users at the golf course
TP23	Moved due to site users at the golf course
TP24	Moved due to site users at the golf course
TP26	Moved away from overhead power cables
TP27	Moved due to ecological constraints
TP28	Moved due to ecological constraints
TP30	Moved away from overhead power cables
TP31	Moved due to ecological constraints
TP32	Moved due to ecological constraints
TP33	Moved due to ecological constraints
TP34	Moved due to ecological constraints
TP35	Moved due to ecological constraints
TP36	Soakaway could not be undertaken due to land drain present at location
TP37	Moved due to ecological constraints
TP38	Moved due to ecological constraints, Terminated shallower due to smaller machine due to access
TP40	Moved due to ecological constraints
TP42	Moved due to attenuation tank at location
TP43	Moved due to attenuation tank at location
TP44	Moved due to attenuation tank at location
TP45	Moved due to ecological constraints
TP46	Moved due to ecological constraints
DS03	Location moved due to ecological constraints, final depth of 2.5m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS04	Location moved due to ecological constraints, final depth of 1.6m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS05	Location moved due to ecological constraints, final depth of 2.4m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS06	Location moved due to ecological constraints, final depth of 2.45m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS07	Location moved due to ecological constraints, final depth of 3.6m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS08	Location moved due to ecological constraints, final depth of 2.5m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS09	Location moved due to ecological constraints, final depth of 2.4m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS10	Location moved due to ecological constraints, final depth of 2.6m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS11	Location moved due to ecological constraints, final depth of 1.8m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS12	Location moved due to ecological constraints, final depth of 1.9m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS13	Location moved due to ecological constraints, final depth of 1.8 achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS14	Location moved due to ecological constraints, final depth of 2.25m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS15	Location moved due to ecological constraints, final depth of 2.40m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS16	Location moved due to ecological constraints, final depth of 2.35m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS17	Location moved due to ecological constraints, final depth of 1.7m achieved, dynamic probe follow on added due to shallow refusal on hard strata
DS18	Location moved due to ecological constraints, final depth of 2.08m achieved, dynamic probe follow on added due to shallow refusal on hard strata
BH103	Unable to locate historical borehole, no monitoring undertaken

Note: Red denotes locations not included in the Phase 2,3,4 report

4.2.2 Relevant Exploratory locations

The following exploratory locations have been identified as relevant to the Phase 2, 3, 4 parcels of land (including locations targeted for Western Park and Central Avenue) and therefore included in Section 4.2.4 onwards of this report:

- 20 Boreholes (BH01-BH20);
- 43 Trial pits (TP01-TP38 and TP45,TP46);
- 18 Dynamic Sampling holes with associated dynamic probing;
- 3 Road Cores.

Details of laboratory testing and exploratory logs relating to Western Park & Central Avenue, Green Super Highway (GSH) and Pond 22 can be reviewed in the separately presented Ground Investigation Reports.

4.2.3 Other Fieldwork

Ongoing ecological surveys are being undertaken by AECOM for the monitoring and assessment of the sensitive flora and fauna present at the site. The findings of these reports are presented separately. Additionally, an arboricultural report will be presented separately.

4.2.4 Gas and Groundwater Monitoring

During the 2023 investigation 3 rounds of fieldwork groundwater level monitoring were completed in 46 No. installations, between 2 August and 12 August 2023. A further 6 rounds of post fieldwork groundwater level monitoring were completed in 46 No. installations, between 14th September and 9th November 2023. Full groundwater monitoring records can be reviewed within the GEL 2023 Factual Report in Appendix C.

Section 5.3 presents the plot of groundwater levels from monitoring specific to Phase 2,3, and 4. The results of the groundwater level monitoring has been plotted as contours and indicates that the groundwater flow is towards the River Adur and its tributaries. The contour plots are presented in Appendix J.

The details of installations undertaken across the site are presented in Table 4-3. Details of installations, ground gas and ground water monitoring events can be found within Appendix H.

Table 4-3 Groundwater Installations

Hole ID	Shallow (S)/ Deep (D)	Standpipe Top (m bgl)	Standpipe Base (m bgl)	Strata
BH01	D	4.50	9.50	Weald Clay
BH01	S	0.90	2.20	Residual Soil
BH02	D	2.20	5.50	Residual Soil
BH02	S	0.60	1.70	Residual Soil
BH03	D	3.50	5.00	Residual Soil
BH03	S	0.60	2.00	Residual Soil
BH04	D	3.00	8.00	Weald Clay
BH04	S	0.60	2.00	Residual Soil
BH05	D	1.80	6.00	Residual Soil
BH05	S	0.60	1.20	Residual Soil
BH06	D	4.50	8.00	Weald Clay
BH06	S	0.60	2.00	Residual Soil
BH07	D	3.60	8.00	Weald Clay
BH07	S	0.60	3.00	Residual Soil
BH08	D	4.00	8.00	Weald Clay
BH08	S	0.60	2.50	Residual Soil/Mudstone
BH10	D	1.60	5.20	Alluvium
BH10	S	0.60	1.20	Residual Soil

Hole ID	Shallow (S)/ Deep (D)	Standpipe Top (m bgl)	Standpipe Base (m bgl)	Strata
BH11	D	6.00	10.00	Weald Clay
BH11	S	0.80	1.80	Residual Soil
BH12	D	4.50	10.00	Weald Clay
BH12	S	0.60	2.80	Residual Soil
BH13	D	4.00	10.00	Weald Clay
BH13	S	0.60	3.00	Residual Soil
BH14	D	5.50	10.00	Weald Clay
BH14	S	0.80	1.80	Residual Soil
BH15	D	4.50	10.00	Weald Clay
BH15	S	0.60	2.60	Residual Soil
BH17	D	4.50	8.00	Weald Clay
BH17	S	0.70	2.20	Residual Soil
BH18	D	4.50	8.00	Weald Clay
BH18	S	0.60	3.10	Residual Soil
BH19	D	4.50	8.00	Weald Clay
BH19	S	0.60	2.50	Residual Soil
BH20	D	4.50	8.00	Weald Clay
BH20	S	0.60	2.00	Residual Soil
BH21	D	6.20	10.00	Weald Clay
BH21	S	1.10	2.00	Residual Soil
BH22	D	8.20	11.20	Weald Clay
BH22	S	2.00	2.40	Residual Soil
BH23	D	11.50	15.00	Weald Clay
BH23	S	1.10	2.00	Residual Soil
BH26	D	13.00	16.00	Weald Clay
BH26	S	1.10	2.00	Residual Soil
DS02	D	0.50	2.00	Residual Soil
DS02	S	3.00	4.00	Residual Soil
DS07	D	2.50	3.50	Residual Soil
DS07	S	0.60	1.90	Residual Soil
DS09	D	0.60	2.20	Residual Soil
DS10	D	0.60	2.20	Residual Soil
DS11	D	0.50	1.80	Residual Soil
DS15	D	0.80	2.20	Residual Soil
DS17	D	0.50	1.70	Residual Soil
DS18	D	0.50	1.90	Residual Soil

Note: Red denotes locations not included in the Phase 2,3,4 report

4.3 Laboratory Testing

4.3.1 Description of Geotechnical Tests

Geotechnical laboratory testing was undertaken by GEL on selected samples as scheduled by AECOM. All geotechnical soil and rock testing work was carried out in accordance with the various sections of BS1377:1990 "Methods of tests for soils in civil engineering purposes" and ISRM Suggested Methods 2007 edition to UKAS accreditation where applicable.

Table 4-4 details the geotechnical tests undertaken in this phase of investigation for the purpose of the exploratory locations outlined in Section 4.2.2. It does not include any testing associated with the additional site locations.

Table 4-4 Geotechnical Testing Undertaken in 2023 Investigation

Type of Test	Standard	Number of Tests
Soil	Moisture Content	BS EN ISO 1782-1:2014:5232
	Four Point Plastic Limit and Liquid Limit	BS EN ISO 17892-12:2018107
	Particle Size Distribution by Wet Sieving	BS EN ISO 17892-4:2016: 5.2110
	Particle Size Distribution by Pipette	BS EN ISO 17892-4:2016: 5.4108
	Dry Density/Moisture Content Relationship using 2.5kg rammer	BS1377:1990 Part 4: 3.2, 3.3, 3.413
	Dry Density/Moisture Content Relationship using 4.5kg rammer	BS1377:1990 Part 4: 3.5, 3.61
	California Bearing ratio on re-compacted disturbed sample	BS1377:1990 Part 4: 714
	One-dimensional consolidation properties	BS EN ISO 17892-5:201711
Undrained shear strength of a Single 70mm and 100mm Diameter specimen in triaxial compression without the measurement of pore pressure	BS EN ISO 17892-8: 201812	
Rock	Point Load Test	ISRM Suggested Methods 2007 edition116
	Unconfined Compressive Strength	ISRM Suggested Methods 2007 edition22
Chemical	BRE Suite D	BS1377:1990 Part 3 BRE SD18
	Organic Matter Content	BS1377:1990 Part 329

4.3.2 Description of Geo-environmental Tests

242 soil samples were taken during the excavation of 20 Rotary Core Boreholes (BH01-20), 18 Dynamic Sampling Boreholes (DS01-18), 3 Road Cores (RC01-03) and 42 Trial Pits (TP01-39, 41, 45-46) with total samples scheduled presented in Table 4-5. A detailed breakdown is included within Appendix I, with soil analysis within Table 10-6, leachate chemical analysis within Table 10-7 and groundwater chemical analysis found within Table 10-8.

Table 4-5 GeoEnvironmental Testing Undertaken in 2023 Investigation

Type of Test	Standard	Number of Tests
Suite E – Asbestos Screen, Metal Analysis (As, B, Cd, Cr III + VI, Cu, Pb, Hg, Ni, Se, Zn) Nitrate, pH, Ammoniacal Nitrogen as N, Sulphate, Total Organic carbon, Speciated polyaromatic hydrocarbons (USEPA 16) + coronene, Moisture content and TPH C6-C40.	MCERTS/ UKAS	124
Semivolatile organic compounds [SVOCs] Suite (exc. PAHs)	MCERTS/ UKAS	28
Volatile organic compounds [VOCs] Suite	MCERTS/ UKAS	28
Poly-chlorinated biphenyls [PCBs] (EC 7 and WHO 12)	MCERTS/ UKAS	8
Criteria Working Group Total Petroleum Hydrocarbons with aliphatic and aromatic split – [TPH CWG] & BTEX/ MTBE	MCERTS/ UKAS	27
Free cyanide, total cyanide and thiocyanate	MCERTS/ UKAS	26

Type of Test		Standard	Number of Tests
Leachate	Extractable petroleum hydrocarbons [EPH] interpretation	MCERTS/ UKAS	19
	Pesticides/herbicides	MCERTS/ UKAS	
	Organo-Chlorine Suite, Organo-Phosphorous Suite, Triazine Suite, Urea Herbicide Suite, Synthetic Pyrethroid Suite, Carbamate Herbicide Suite, Glyphosate, Organo Tins		14
	2-stage Waste Acceptance Criteria [WAC]	MCERTS/ UKAS	15
	Suite F – Metal Analysis (As, B, Cd, Cr III + VI, Cu, Pb, Hg, Ni, Se, Zn), pH, Sulphate (as SO ₄), TPH CWG with aliphatic and aromatic split, Nitrate as N, Nitrite, Speciated polycyclic aromatic hydrocarbons (USEPA 16), Free cyanide and total cyanide and Ammoniacal nitrogen expressed as N	UKAS	19
	SVOCs suite	UKAS	10
	VOCs suite	UKAS	10
	PCBs (7 congeners)	UKAS	2
	Pesticides/herbicides		
	Organo-Chlorine Suite, Organo-Phosphorous Suite, Triazine Suite, Urea Herbicide Suite, Synthetic Pyrethroid Suite, Carbamate Herbicide Suite, Glyphosate, Organo Tins	UKAS	4
Groundwater	2-stage Waste Acceptance Criteria [WAC]	UKAS	15
	Suite F – Metal Analysis (As, B, Cd, Cr III + VI, Cu, Pb, Hg, Ni, Se, Zn), pH, Sulphate (as SO ₄), TPH CWG with aliphatic and aromatic split, Nitrate as N, Nitrite, Speciated polycyclic aromatic hydrocarbons (USEPA 16), Free cyanide and total cyanide and Ammoniacal nitrogen expressed as N	UKAS	30
	SVOCs suite	UKAS	11
	VOCs suite	UKAS	11
	Pesticides/herbicides		
	Organo-Chlorine Suite, Organo-Phosphorous Suite, Triazine Suite, Urea Herbicide Suite, Synthetic Pyrethroid Suite, Carbamate Herbicide Suite, Glyphosate, Organo Tins	UKAS	6
	BRE Suite D - pH, water soluble sulphate, Total sulphur, Acid soluble sulphate	UKAS	8

5. Ground Model

5.1 General

An interpretation of the existing information and the results from field and laboratory studies has been carried out, upon which the following ground model is presented.

5.2 Summary of Strata Encountered

Based on the results of the ground investigation a general ground model has been derived for the site. The ground model is presented in Table 5-1. The average ground level across the locations undertaken as part of the Phase 2, 3, 4 land parcels within the site was 25.6mAOD. A maximum elevation of 33.3mAOD was encountered towards the west of the site at E:529237 N:120516 (TP03) and a minimum elevation of 17.51mAOD towards the south of the site at E:530012 N:120442 (BH10).

Table 5-1 Ground Model

Strata	Depth to top (m bgl)	Depth to base (m bgl)	Thickness (m)	General Description
Topsoil*	0	0.2-0.3	0.2-0.3	Grass over stiff light brown slightly sandy slightly gravelly silty clay. Gravel is sub-rounded fine and medium mudstone.
Made Ground	0	0.3-1.8	0.3-1.8	Variable across site. See Section 6.3 for details. Generally reworked Topsoil with gravel comprising flint, siltstone brick. Occasional Chalk and Concrete noted. Tarmacadam present in Road Cores (RC01-RC03)
Alluvium**	1.4	4.8	3.5	Very soft light bluish grey to dark brown slightly sand silty organic clay with rare to frequent fragments of decomposed plant material
Weald Clay-Residual Soil/Completely Weathered (Grade V and VI)	0.3-1.8	0.7-9.3	0.4-9.0	Stiff to very stiff, locally firm. Brown-grey occasionally mottled orange slightly gravelly slightly sandy silty clay with occasional to frequent lenses of light grey silt. Occasionally described as stiff thinly and thickly laminated light grey mottled orangish brown clayey silt locally tending to siltstone with black straining and reddish-brown staining. Tending to extremely weak mudstone or Siltstone. Gravel layers found within the Weald Clay include very weak to medium strong light grey siltstone or fine sandstone.
Weald Clay- Slightly to Unweathered (Grade I to IV)	0.7-9.3	Base not encountered	0.4-17.9***	Extremely weak to very weak light bluish grey mudstone with very closely and closely spaced thick laminae to very thin beds of medium strong light yellowish brown calcareous mudstone.

Notes:

*The Topsoil was not separated from underlying strata, although it is anticipated that the thickness of Topsoil on the site is between 0.2 and 0.3m.

**Alluvium was only encountered in one exploratory locations. The borehole is located in the southwest of the site within the lower lying ground associated with extents of river alignment as shown in Figure 3-1 Topographical mapping.

*Base not encountered

** Variation present within logged descriptions of Residual Soil. The silt and clay horizons are interpreted to be the same soil however recorded differently by GEL on site logs.

*** Not fully penetrated

5.3 Summary of Groundwater Conditions

Groundwater strikes and seepages were encountered in 11 of the exploratory locations within the Phase 2, 3, 4 GI completed in 2023. These are summarised in Table 5-2.

Table 5-2 Groundwater Strike Summary

Exploratory Hole	Strike Level (m bgl)	Strike Level (m AOD)	Strike Geology	Max Rise (m bgl)	Max Rise (m AOD)
BH10	1.7	15.8	Alluvium	Seepage only	
BH11	1.6	25.7	Residual Soil	1.4	25.7
BH24	1.3	25.3	Residual Soil	0.0	26.6
DS09	1.2	32.1	Residual Soil	1.2	32.1

Exploratory Hole	Strike Level (m bgl)	Strike Level (m AOD)	Strike Geology	Max Rise (m bgl)	Max Rise (m AOD)
DS09	2.0	25.3	Residual Soil	2.0	25.3
RC02	1.1	22.6	Residual Soil	0.0	23.7
TP01	1.9	16.8	Residual Soil	Seepage only	
TP01	2.9	15.1	Residual Soil	Seepage only	
TP03	2.9	18.5	Residual Soil	Seepage only	
TP07	2.6	21.7	Residual Soil	Seepage only	
TP31	2.9	14.8	Weathered Weald Clay	Seepage only	
TP33	2.4	21.9	Residual Soil	Seepage only	
TP34	3.0	20.8	Residual Soil	Seepage only	

During the 2023 investigation 3 rounds of fieldwork groundwater level monitoring were completed in 46 No. installations, between 2 August and 13 August 2023. Further monitoring rounds were completed post fieldwork due to equipment and weather difficulties some locations were only monitored for 4 rounds whilst the remainder received 6 rounds of post fieldwork, between 14 September and 10 November 2023. Full groundwater monitoring records can be reviewed within the GEL 2023 Factual Report in Appendix C.

Figure 5-1 and Figure 5-2 present plots of groundwater levels from monitoring specific to Phase 2, 3, 4. The results show that the groundwater level was consistent and not significantly affected by rainfall.

The groundwater was encountered in the Residual Soil near surface and Weathered Weald Clay in the deep groundwater installations. Groundwater fluctuations within the standpipe in BH22 may relate to its installation within medium strong Sandstone, below which is a moderately weak mudstone. The sandstone is potentially more permeable and groundwater levels may reflect changes in recharge.

When plotted against elevation the depth to groundwater corresponds with changes in ground level. For example, the groundwater level at BH20 and BH01 is at a higher elevation than within BH10 and BH11 which are topographically lower and adjacent to the stream. Conversely when plotted on depth below surface the results from BH10 are shown to plot the closest to surface suggesting the groundwater is potentially in hydraulic conductivity with surface water features.

Groundwater contour plots are presented within Appendix J.

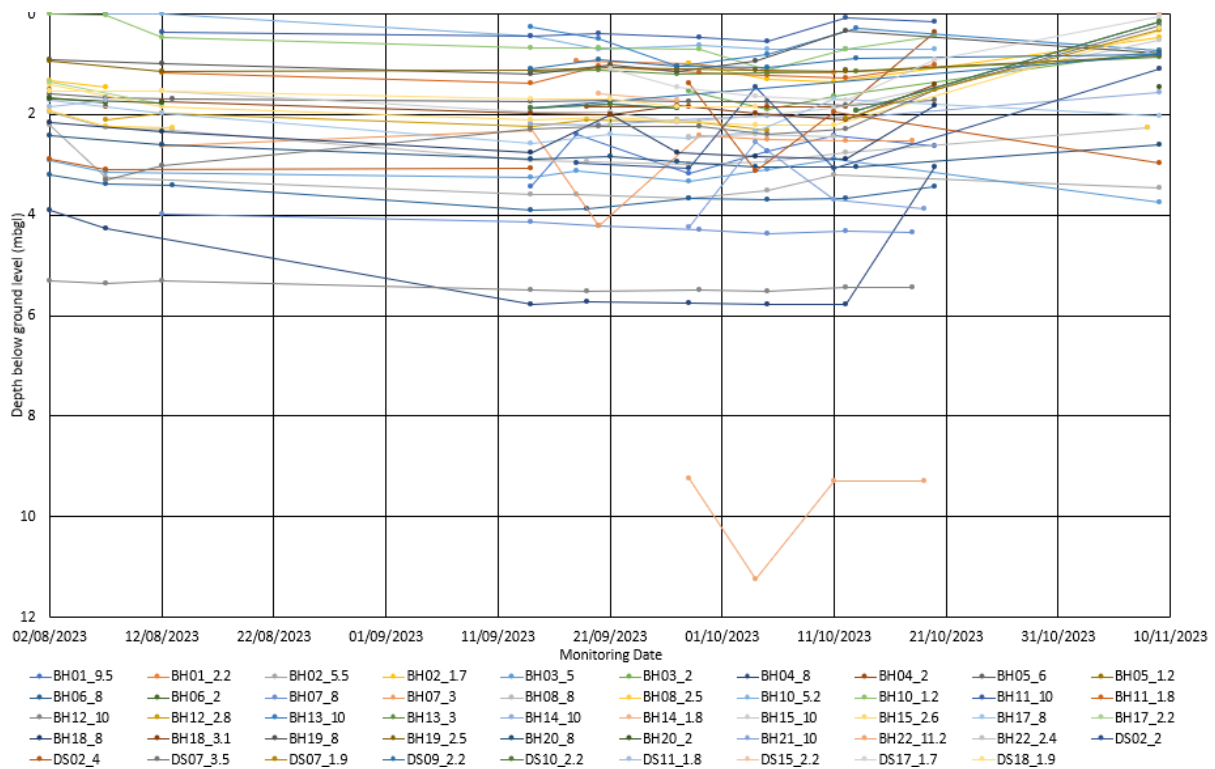


Figure 5-1 Groundwater monitoring depth below ground level

On Figure 5-1 BH01_1 refers to Borehole Identification and Standpipe Base.

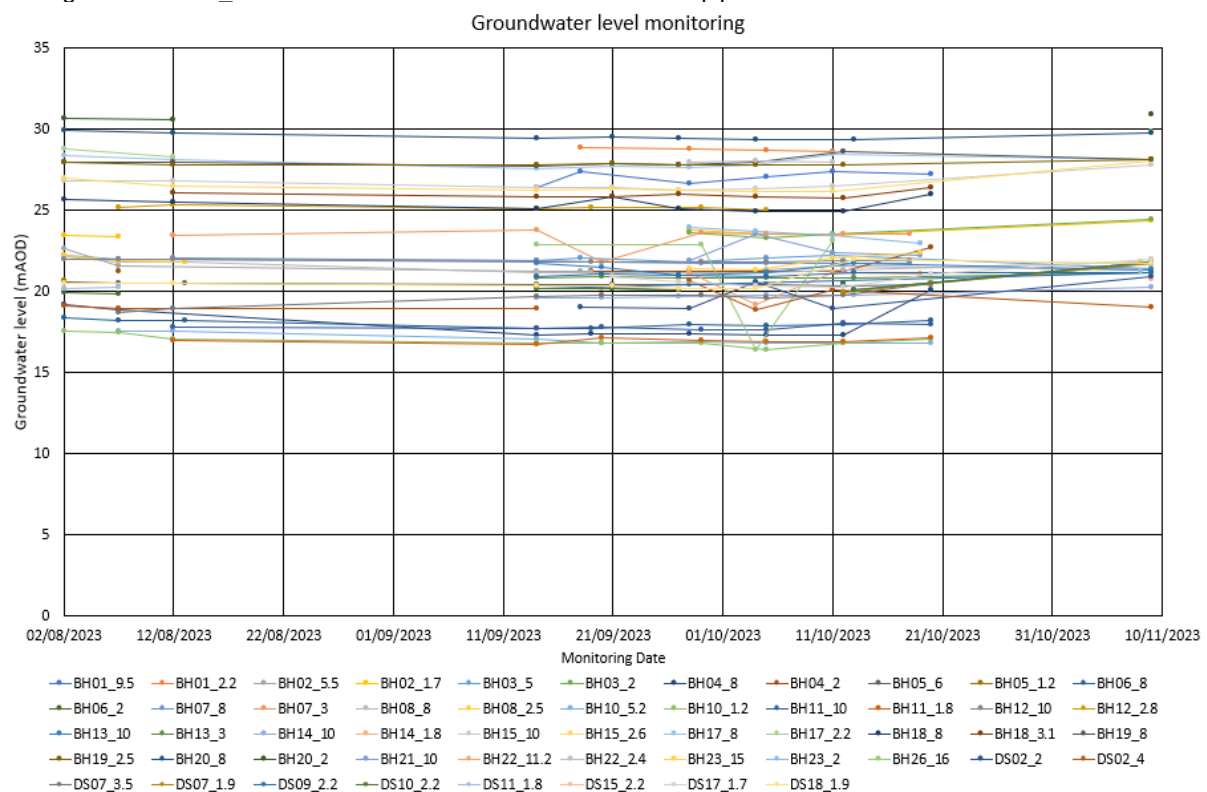


Figure 5-2 Groundwater monitoring metres above ordnance datum

In Figure 5-2 BH01_1 refers to Borehole Identification and Standpipe Base.

6. Ground Conditions and Material Properties

6.1 General

6.1.1 Infilled Ponds/ Clay Pits

Of the locations targeting historical ponds/clay pits only TP46 identified Made Ground to a depth of 0.40m bgl comprising gravelly silty clay where gravel was subangular to subrounded fine to coarse mudstone, siltstone with rare brick and concrete. The trial pit was located adjacent to two historical rectangular structures assumed to be farm buildings which are shown in place until the 1992 historical mapping.

6.1.2 Weald Clay Formation

Where encountered on site the Weald Clay Formation varies from stiff clays to medium strong mudstones, siltstones and sandstones.

The Weald Clay is encountered as Residual Soil/Completely Weathered soil beneath Topsoil, Made Ground and locally Alluvium at the site. The depth to rockhead is understood to be variable and subject to interpretation at the site due to the in-situ strength testing (i.e. SPTs) refusing within the weathering profile. and variation within strength descriptions within the interbedded lithologies.

The classification of the Weald Clay has been interpreted based on Fookes (1997) scale of weathering grades of rock mass. Based on the soil and rock descriptions within the logs, attached as Appendix C, Grade II to Grade I Weald Clay have been considered as rockhead for the purpose of this analysis and to have rock derived parameters.

Overlying the Grade I and II rock the Weathered Weald Clay was generally encountered as soil Grade III and IV were largely absent being occasionally represented by more resistant siltstone and sandstone beds in the soil. Residual Soil/ Completely weathered (Grade V and VI) in this report, in most exploratory locations, is noted as stiff clays tending to extremely weak rock at the base of these grades. This stratum has been characterised by soil parameters only.

6.2 Topsoil

Topsoil was encountered in 75 No. exploratory holes from surface level. The factual report does not separate Topsoil from the underlying strata, although it is anticipated that the thickness of Topsoil on the site is between about 0.2m and 0.3m.

It is recommended that Topsoil material is stripped from the footprints of earthworks and structures prior to construction and stockpiled on site for re-use. As a result, in-situ Topsoil will not be considered in the stability analyses of earthworks and structures. Consequently, no geotechnical parameters have been derived for the in-situ material.

Site won Topsoil may be suitable for re-use as a Specification for Highway Works Class 5A Topsoil material. Depending on the scheme's landscaping proposals, specific testing may be required to determine if the Topsoil is suitable for use as a planting medium.

6.3 Made Ground

Made Ground was encountered in 8 exploratory holes; BH07, RC01, RC02, RC03, TP03, TP15, TP24 and TP46, which are mainly located centrally on site.

Phase 4A

Within BH07 Made Ground was encountered to a thickness of 0.30m bgl described as reworked Topsoil with gravel angular to subrounded fine to coarse of flint, siltstone and rare brick. BH07 is located within the vicinity of a rectangular historical farm building shown on mapping between 1899 and 1994.

Central Avenue

RC01 to RC03 are associated with the Cuckfield Road, within the Road Cores RC01 to RC03. The Made Ground was described as Tarmacadam from surface to 0.13m bgl and 0.15m bgl, becoming dark grey and black silty gravelly fine to coarse sand. Concrete was encountered in RC02 from 0.13m bgl to 0.3m bgl. Gravel is angular and subangular fine to coarse crystalline and coal and flint and was found to a depth of up to 0.75m bgl.

Western Park

TP03 is located within the vicinity of Floods Barn shown on historical mapping and associated ponds from 1897 to 1975. The Made Ground present may therefore be due to previous infilling of ground. The Made Ground was described as subrounded fine to coarse gravel of flint limestone chalk and rare brick with rare wood fragments from surface to 0.5m, becoming firm and stiff greyish slightly sandy gravelly silty clay with rare rootlets and faint organic odour. Gravel is angular to subrounded fine and medium flint limestone chalk and rare brick.

Phase 2C

TP15 is located adjacent to Bridge Farm Cottages shown on historical mapping since 1937. The Made Ground was found to an extent of 1.30m depth. It is described as very stiff brown slightly sandy slightly gravelly silty clay with frequent rootlets. Gravel is subangular coarse brick until 0.20m bgl becoming very stiff brown light blueish grey mottled brown silty clay until 1.15m where a ceramic drainage pipe was encountered.

TP46 is located near to an existing pond in addition historical mapping showed two small buildings present from 1938 to 1974 north of the pond potentially being the source of Made Ground. The Made Ground was encountered from surface to 0.40m bgl and is described as stiff brown slightly sandy slightly gravelly silty clay. The gravel is subangular to rounded fine to coarse mudstone, siltstone and rare brick and concrete.

Phase 3B

TP24 is shown south of the site at the golf course, the Made Ground was to a depth of 0.30m and comprised of silty clay with rare fine gravel sized fragments of glass and ceramics. The following tests were undertaken in the Made Ground:

- 3 No. Natural moisture content determination
- 3 No. Atterberg Limits
- 8 No. Lightweight Deflectometer Tests
- 2 No. Particle Size Distribution (PSD) by wet sieving
- 2 No. Particle Size Distribution (PSD) by pipette
- 4 No. Hand shear vane tests (within TP15 and TP46).

Made Ground is generally very variable and can change laterally and with depth. The parameters detailed below should be used with caution as they may not be suitable for all Made Ground encountered during construction. In addition areas of Made Ground may be encountered during construction that were not found during this exploratory phase ground investigation.

6.3.1 Classification Tests

The results of the natural moisture content and Atterberg Limits tests for Made Ground are presented in Table 6-1. The Made Ground ranges from an intermediate to high plasticity clay.

Table 6-1 Classification Tests Made Ground

Hole ID	Depth top (m bgl)	MC %	LL %	PL %	PI %	% passing 425 µm	I _p (%)
BH10	1.0	26	42	22	20	89	18
BH07	0.1	18	47	25	22	83	18
TP03	0.5	17	51	22	29	55	16

The modified plasticity index I_P has been calculated between 16% and 18% in accordance with NHBC guidelines and the material has a low volume change potential. A bulk unit weight of between 17 and 19 kN/m³ is recommended for the Made Ground based on the soil descriptions and typical values for similar soils presented in Table 1 BS8002.

Table 6-2 shows the results of the 2 No. PSD tests. The results show that all the samples tested comprised of fine grained soil (silt and clay), with 11% and 13% sand, and 15% and 27% gravel.

Table 6-2 Particle Size Distribution Made Ground

Hole ID	Depth (m bgl)	% cobbles	% gravel	% sand	% silt	% clay	% fines
BH07	0.1	0	15	13	57	16	73
TP03	0.5	0	27	11	33	29	62

6.3.2 Surface Modulus and California Bearing Ratio

6.3.2.1 Light Weight Deflectometer Testing

A total of 8 No. Light Weight Deflectometer (LWD) tests were undertaken adjacent to 4 No. trial pit locations containing Made Ground as reported in Appendix G.

The surface modulus (E_0) has been calculated by Geotechnical Engineering Ltd, which range from 28.7 MPa to 102.0 MPa, with a lower quartile of 37.5 MPa. It is worth noting the LWD test devices may not be suitable for thicker stiffer pavement foundations (IAN 73/06 Rev 1). The zone of influence for the test typically extends to between 1 and 1.5 times the plate diameter, beyond the extent of Made Ground.

The result from the LWD testing was used to calculate the California Bearing Ratio (CBR). In accordance with CD225, equation 2.4, $E = 17.6(CBR)^{0.64}$ has been used to estimate CBR values. However, this equation is only valid for CBR values in the range of 2%-12%. Therefore, 2 No. LWD tests were not included in the assessment since their CBR values exceeded 12%. The lower quartile of the remaining values gives a CBR value of 3%. This should be adopted for design if lower than the equilibrium value indicated in section 6.3.2.2 from TRRL LR1132.

Guidance from CD 225 Revision 1 states that when the subgrade surface modulus is lower than 30 MPa (about 2.5% CBR), improvement of the subgrade shall be undertaken. 1No. LWD test produced a surface modulus under 30MPa, TP15 at ground level (0.00m). It should be noted that the results of tests carried out at ground level (0.00m) should be used with caution. It is recommended that all surface soils be stripped prior to construction.

CD225 also states that foundations built on a construction subgrade surface modulus of 50 MPa (about 5% CBR) or less have a relatively high risk of structural rutting during construction. This can be prevented through subgrade improvement and/or the use of a capping layer.

6.3.2.2 Plasticity Index

Equilibrium CBR for the cohesive Made Ground has been estimated from the plasticity index range of 20% to 29%, with an upper quartile of 26%, and material composition in accordance with TRRL Laboratory Report 1132, 1984 'The Structural Design of Bituminous Roads'. A CBR value of 3.5% can be adopted based on thin construction and 5.0% based on thick construction. TRRL LR1132 defines a thick pavement as 1200mm thick including a 650mm capping layer while thin pavement is 300mm thick.

The CBR value assumes a high water table (defined as 300mm beneath formation level) and good construction conditions. Good construction conditions are defined by TRRL LR1132 as those where the subgrade never gets wetter than the equilibrium moisture content beneath the finished road. In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

6.3.3 Undrained Shear Strength

The undrained shear strength of Made Ground was recorded on 4 No. samples using hand shear vanes and pocket penetrometers. The hand shear vanes recorded the undrained shear strength as >150kPa in TP15 at 0.5m bgl and TP46 at 0.1m bgl in stiff to very stiff clay material. The pocket penetrometer recorded the undrained shear strength in TP03 at 1.0m bgl and TP24 at 0.3m bgl. The results ranged from 162kPa to 187kPa within the firm to stiff silty clay of TP03. The test of TP24 recorded a value of 225kPa.

6.3.4 Drained Shear Strength

For drained shear strength of cohesive Made Ground the proposed correlation by Santamarina et al., (2003) has been used to estimate the effective constant volume angle of shearing resistance ϕ'_{cv} based on the returned plasticity indices (I_p) of the Made Ground from Atterberg Limit Classification Testing summarised in Section 6.3.1. The following formula was used;

$$\phi'_{cv} = 42^\circ - 12.5 \log_{10}(I_p)$$

The Plasticity Index results ranged between 20% and 29% with an average of 24%, resulting in the correlated ϕ'_{cv} between 24° to 26° with an average of 25°.

6.3.5 Stiffness

The undrained stiffness (E_u) of the Made Ground can be obtained by using the relationship proposed by Jamiolkowski et al., (1979) which correlated E_u/C_u ratio to I_p and OCR. For an I_p of 24% and an OCR of 1 (a normally consolidated soil), an E_u/C_u ratio of 300 is obtained, yielding an average stiffness of between 45MPa to 56MPa, based on an undrained shear strength range of 150kPa to 187kPa.

6.4 Alluvium

Alluvium was only encountered in one exploratory location (BH10) in the southwest section of site. It is anticipated that it may be present in other locations within the vicinity of the River Adur and its associated tributaries.

Within BH10, it was recovered as very soft light bluish grey to dark brown slightly sand silty organic clay with rare to frequent fragments of decomposed plant material from 1.4m bgl to 4.85m bgl.

The following tests were undertaken in the Alluvium:

- 3 No. Standard Penetration Tests (SPT)
- 2 No. Natural moisture content determination
- 2 No. Atterberg limits
- 2 No. Particle Size Distribution (PSD) by wet sieving
- 2 No. Particle Size Distribution (PSD) by pipette
- 3 No. Organic Matter Tests

6.4.1 Classification Tests

Natural moisture content and Atterberg Limits test results are shown in Table 6-3. The natural moisture contents are close to the liquid limit supporting the low undrained shear strength derived from the SPTs as discussed in section 6.4.2.

The Alluvium is shown to be an intermediate plasticity clay as presented in Figure 6-1 with a Liquid Limit between 40% and 47%. The modified plasticity index I'_p has been calculated between 18% and 21% in accordance with NHBC guidelines. This indicates that the material has a low to medium volume change potential.

Table 6-3 Classification Tests Alluvium

Hole ID	Depth (m bgl)	MC %	LL %	PL %	PI %	% passing 425 μ m	I'_p (%)
BH10	2.3	37	40	22	18	100	18
BH10	3.4	68	47	26	21	98	21

Based on typical values for similar soils presented in BS8002, the suggested bulk unit weight of 18kN/m³ may be adopted for design purposes.

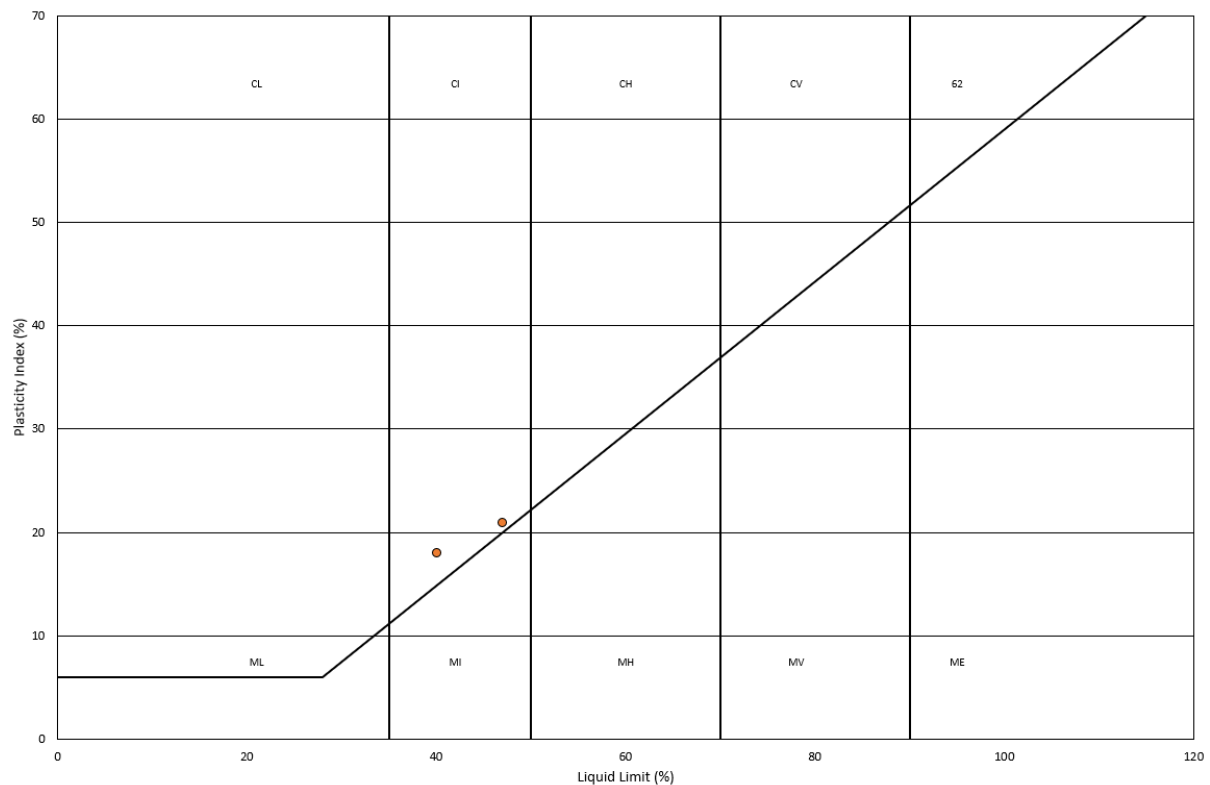


Figure 6-1 Casagrande Plot for Alluvium

Table 6-4 presents the results of the 2 No. PSD tests. The results show that all samples tested comprised of fine grained soil (silt and clay), with between 2% and 7% sand, and between 0% and 1% gravel.

Table 6-4 Particle Size Distribution Alluvium

Hole ID	Depth (m bgl)	% cobbles	% gravel	% sand	% silt	% clay	% fines
BH10	2.3	0	0	2	72	27	99
BH10	3.4	0	1	7	62	31	93

Within the Alluvium three organic matter content tests undertaken returning results of 4.5% to 6.2% within BH10 between 1.75m and 3.8m bgl. BS5930 indicates that soils with organic contents of 2% to 6% have low organic content.

6.4.1.1 Standard Penetration Test

3 No. Standard Penetration Tests were undertaken in the Alluvium in BH10. The N and N₆₀ values range between 0 (self weight penetration) and 1.

6.4.2 Strength

6.4.2.1 Undrained Shear Strength

Based on the SPT results and using the Stroud correlation, $c_u(\text{kPa}) = f_1 \times N_{60}$ (where $f_1=5.0$ for Plasticity Index of 20%), undrained shear strength values have been derived between 0kPa and 6kPa.

6.4.2.2 Drained Shear Strength

For drained shear strength the proposed correlation by Santamarina et al., (2003) has been used to estimate the effective constant volume angle of shearing resistance ϕ'_{cv} based on the returned plasticity indices (I_p) of the Alluvium from Atterberg Limit testing summarised in Section 6.4.1. The following formula was used;

$$\phi'_{cv} = 42^\circ - 12.5 \log_{10}(I_p)$$

The Plasticity Index results were 18% and 37%. resulting in the correlated ϕ'_{cv} of 22° and 26°.

6.4.3 Stiffness

The Jamiolkowski et al. (1979) correlation can be used to derive the undrained Young's Modulus where:

$$E_u = 300 * C_u$$

This gives an undrained Young's Modulus ranging between 0 MPa and 2 MPa, based on the C_u values range between 0 kPa and 6 kPa.

Assuming linear elasticity, the drained Young's Modulus can be estimated according to the following formula where ν' is estimated to be 0.25.

$$E' = E_u * 2 \frac{(1 + \nu')}{3}$$

This results in values ranging between 0 MPa and 2 MPa.

6.5 Residual Soil – Grades V and VI

Weald Clay weathered to Residual Soil and Completely weathered soil was encountered in 83 No. Locations across the site. In the following Grade V and VI are both referred to as Residual Soil.

The top of the Residual Soil was therefore encountered between 0.3m bgl and 1.8m bgl to a maximum depth of 9.3m bgl as presented in Figure 6-2.

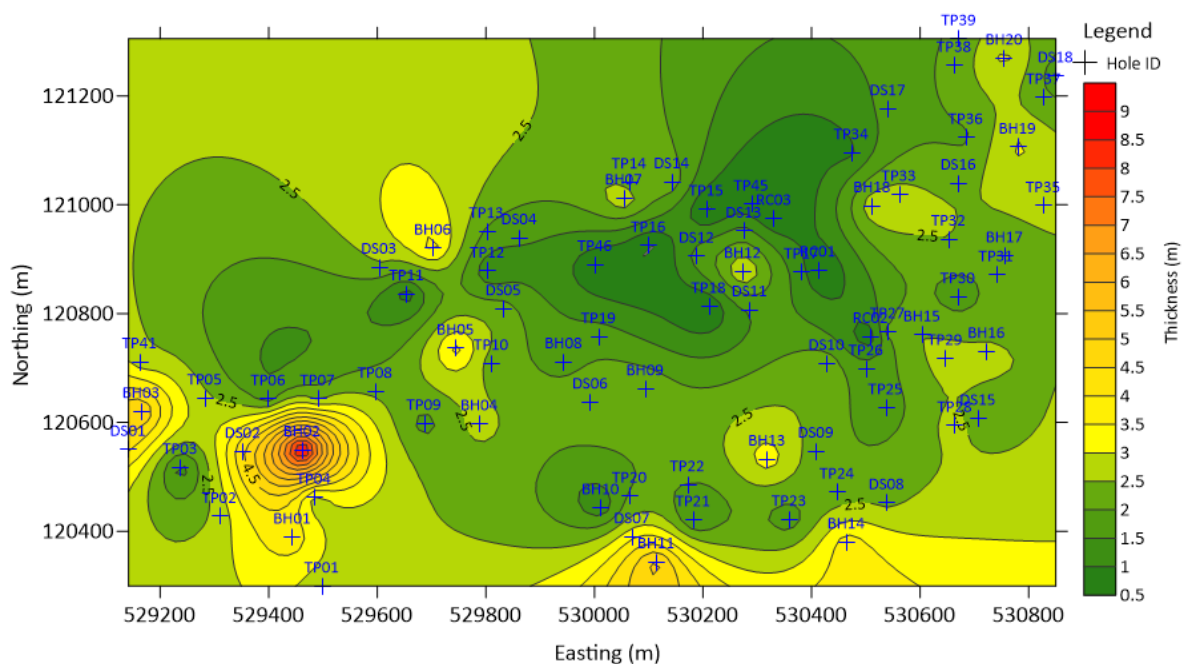


Figure 6-2 Thickness of Residual Soil

(This figure has been generated using Golden Software: Surfer to interpolate a raster surface from a series of points. The mapping generated should be used with caution especially where the density of data points is limited.)

The Residual soil was at its maximum extents near to the river and streams present at the site. The description of Residual Soil varied across the site. It is typically described as stiff to very stiff, locally firm, brown-grey occasionally mottled orange slightly gravelly slightly sandy silty clay with occasional to frequent lenses of light grey silt.

The Residual Soil showed to increase in gravel content from 1.0m bgl. The soil was occasionally described as stiff thinly and thickly laminated light grey mottled orangish brown clayey silt locally tending to siltstone with black and reddish-brown staining. The unit was also found to be tending to extremely weak mudstone or siltstone.

Gravel bands, where present, are shown to be between 0.20m thickness and 0.6m thickness, these gravel layers are expected to be more resistant to weathering. Lithorelics within the samples were described as fine to coarse of Siltstone, Mudstone and rare Sandstone.

The following tests were undertaken in the Residual Soil:

- 61 No. Standard Penetration Tests (SPT)
- 139 No. Natural moisture content determination
- 139 No. Atterberg limits
- 115 No. Lightweight Deflectometer Tests
- 16 Laboratory CBR
- 131 No. Particle Size Distribution (PSD) by wet sieving
- 130 No. Particle Size Distribution (PSD) by pipette
- 12 No. Dry Density/Moisture Content Relationship Tests – 2.5kg
- 16 No. Undrained Unconsolidated Triaxial
- 10 No. One-dimensional Consolidated test
- 54 No. Hand shear vane tests (HSV)
- 37 No. Hand Penetrometer Tests
- 24 No. Organic Matter Tests

6.5.1 Classification Tests

The natural moisture content and Atterberg Limit test results for Residual Soil are presented in Table 6-5 from a total of 139 samples. Excluding one test from TP34 at 1.5m bgl described as brown slightly sandy very clayey gravel by the laboratory test record and very stiff clay on the borehole log.

Table 6-5 Classification Tests Residual Soil

Hole ID	MC %	LL %	PL %	PI %	% passing	I _p (%)
					425 µm	
Minimum	11	40	19	15	32	8
Maximum	60	90	33	57	100	56
Average	22	54	25	29	89	26
Lower Quartile	16	46	24	22	85	20

Natural moisture content and Atterberg Limits test results for Residual Soil are shown in Figure 6-3. The natural moisture content generally plots close to or below the plastic limit, with many plastic limits being equal to the moisture content. Therefore, some of the material is anticipated to behave in a plastic manner when in its in situ state.

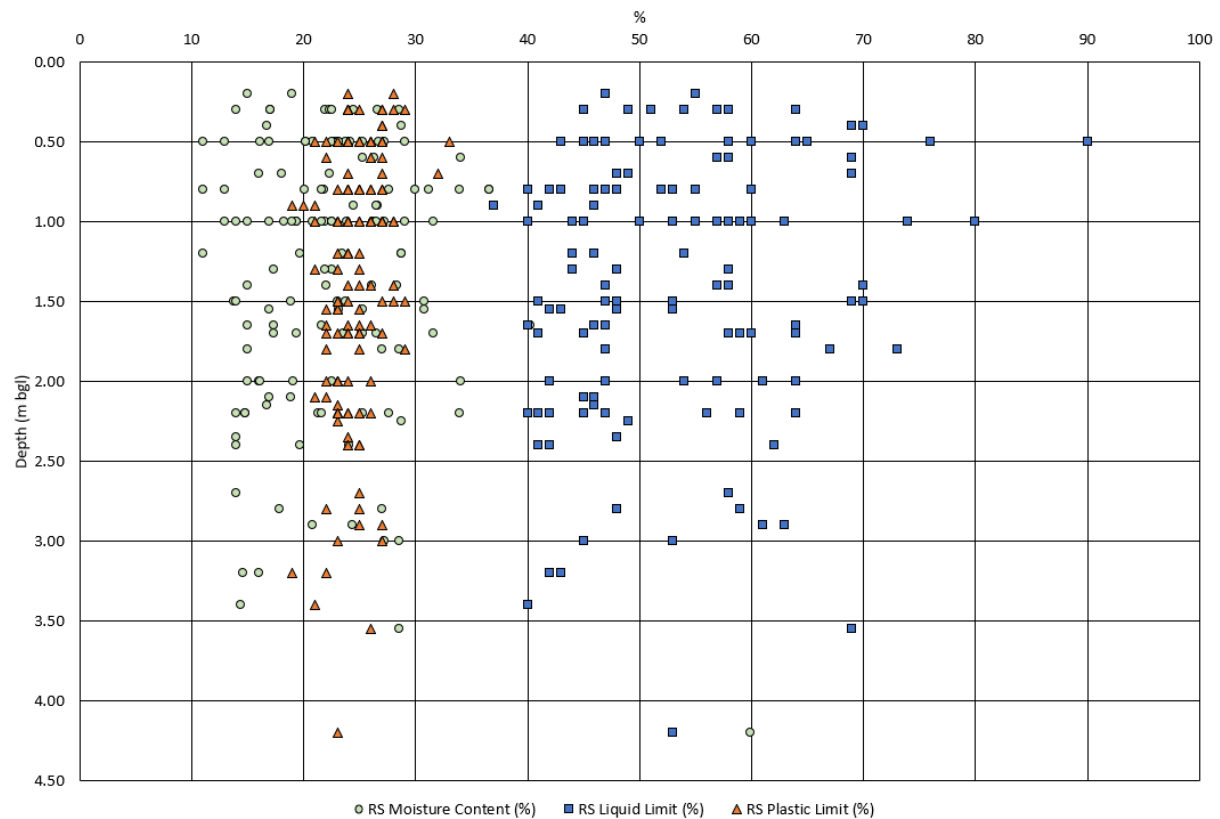


Figure 6-3 Residual Soil: Moisture Content and Atterberg Limits

Based on the Casagrande A-line plot in Figure 6-4, generally, the Residual Soil ranges from an intermediate to very high plasticity clay and silt. The modified plasticity index I'_p has been calculated between 8% and 56%, with a lower quartile of 20%, in accordance with NHBC guidelines. The PI value of 56% with a LL of 90% is considered an outlier, therefore, the soil can be expected to generally have a medium and high volume change potential.

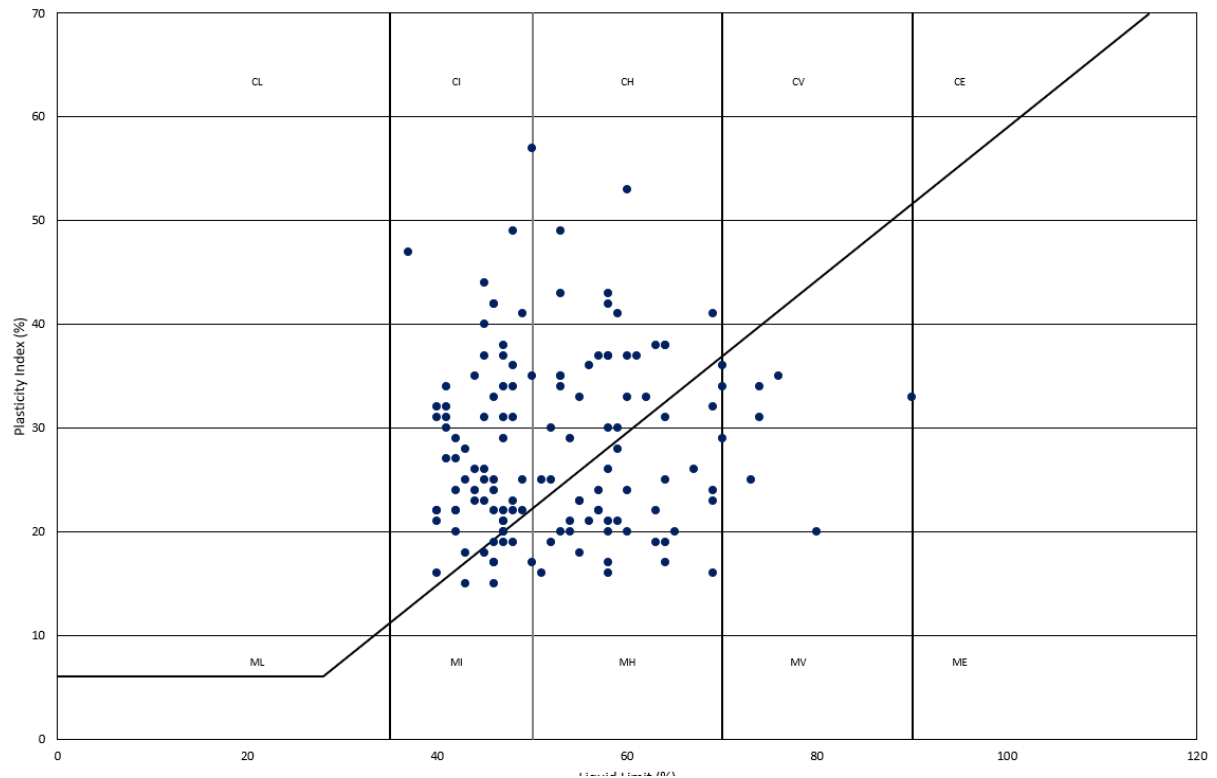


Figure 6-4 Residual Soil Casagrande A-Line Plot

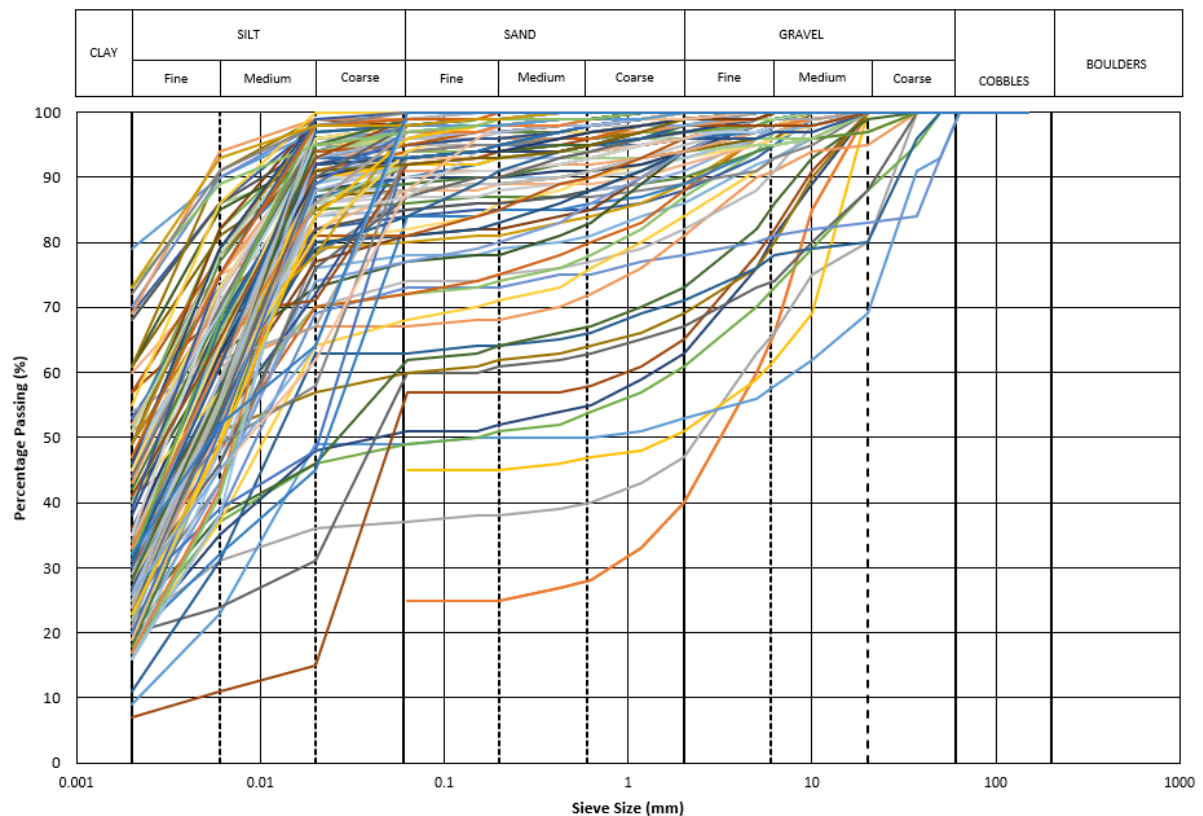


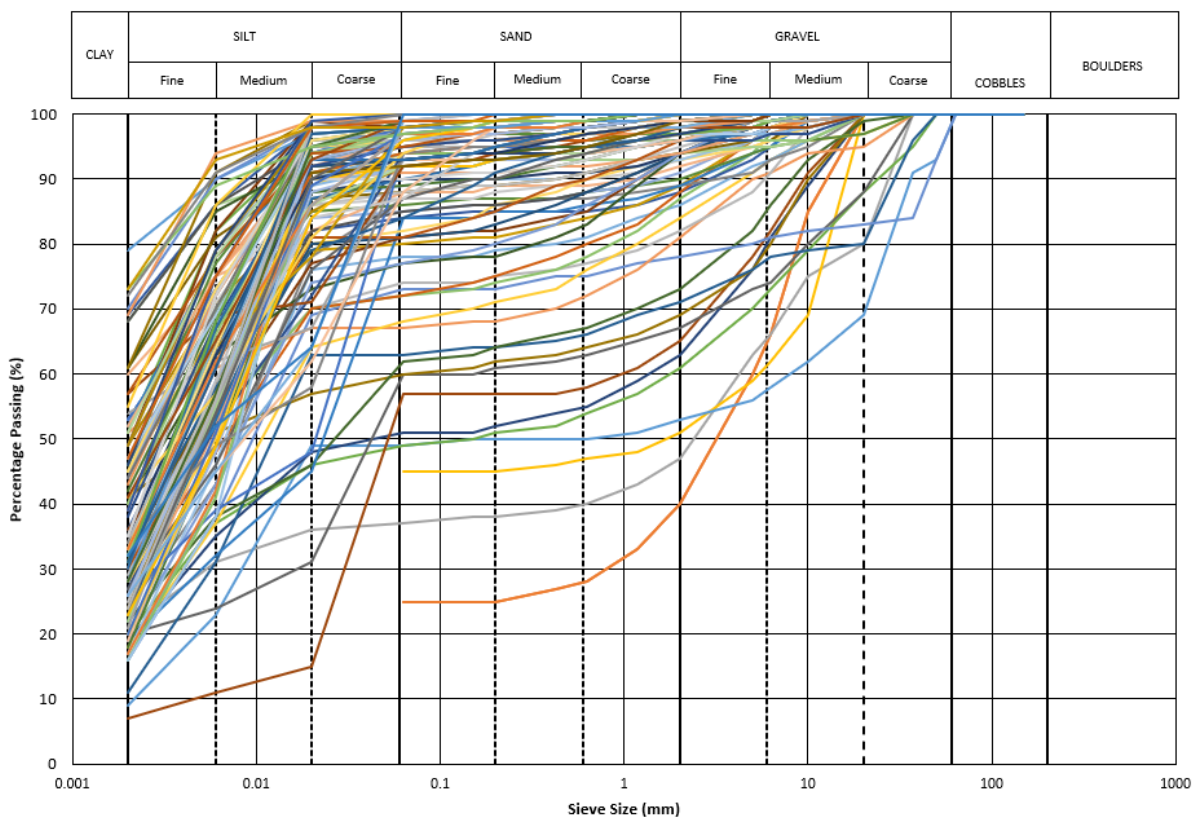
Figure 6-5 present the results of the 131 No. PSD tests. Table 6-6 presents the results of 126 No. PSD tests , the results show that the material is generally comprised of between 49% and 100% of fine-grained soil (silt and clay) with 0% and 17% sand, and 0% and 39% gravel. Table 6-7 presents five samples that had more granular (comprising >50% sand and gravel) content despite laboratory samples describing as clay at depths between 1.0m bgl and 1.5m bgl. Lithorelics within the samples were described as fine to coarse gravel of Siltstone, Mudstone and rare Sandstone. These more gravelly layers are expected to be more resistant to weathering between 0.20m thickness and 0.6m thickness.

Table 6-6 Classification Tests Residual Soil

Statistic	% cobbles	%gravel	%sand	%silt	%clay	%Fines
Minimum	0	0	0	17	7	49
Maximum	0	39	17	82	79	100
Average	0	5	5	54	36	90
Lower Quartile	0	1	2	45	24	88

Table 6-7 Classification Tests Residual Soil- Granular Bands

Hole ID	Description	% cobbles	%gravel	%sand	%silt	%clay	%Fines
TP30_1.0	Light brown mottled grey slightly gravelly slightly sandy silty clay	0	60	15	-	-	25
BH15_2.2	Yellowish brown slightly gravelly slightly sandy silty clay	0	39	12	28	21	49
TP09_1.7	Light brown slightly gravelly slightly sandy silty clay	0	53	10	16	21	37
TP12_1.5	Yellowish brown slightly sandy slightly gravelly silty clay	0	53	10	16	21	37
TP39_1.5	Light brown slightly sandy slightly gravelly silty clay	0	47	3	41	9	50

**Figure 6-5 Residual Soil Particle Size Distribution**

12 No. dry density/ moisture content relationship tests were completed within the Residual Soil. The tests returned moisture contents at optimum between 20% and 28% and maximum dry density results between 1.46Mg/m³ and 1.66Mg/m³. Further information on this can be found in Section 6.5.4.

6 No. bulk density tests were carried out on the Residual Soil as a part of the oedometer tests and undrained triaxial tests and the values ranged from 1.86Mg/m³ to 2.20Mg/m³, with a lower quartile value of 1.95Mg/m³. Based on these results a unit weight of 19kN/m³ is suggested for this material.

Within the Residual Soil 24 No. organic matter content tests were undertaken, assuming 30% is an outlier, the results returned between 1.1% to 7.4%, with a lower quartile of 3.65%. BS5930 indicates that soils with organic contents of 2% to 6% have low organic content.

6.5.2 Surface Modulus and California Bearing Ratio

Laboratory CBR testing was carried out at depths between 0.9m bgl and 2.0m bgl within the Residual Soil on a total of 16 No. bulk samples. The results of these are summarised in Table 6-8. Where soaked tests were undertaken swelling ranged from -0.2mm to 3.3mm. Soaked CBR values range from 0.55 to 1.8 and are considered to represent the worst condition where the subgrade has been allowed to become saturated.

Table 6-8 Residual Soil: CBR summary from Laboratory Testing

Hole ID	Depth	Summary Soil Description	Test type	Natural Moisture content (%)	Bulk Density (Mg/m ³)	CBR Value Top (%)	CBR Value Bottom (%)
RC01	0.90	Greyish brown slightly sandy silty clay	Unsoaked	26.6	1.91	2.3	2.8
RC02	0.90	Yellowish brown mottled greyish brown slightly gravelly slightly sandy silty clay	Unsoaked	26.5	1.92	0.96	1.7
RC03	0.90	Greyish brown slightly gravelly slightly sandy silty clay	Soaked	24.5	1.93	1.6	1.8
TP01	2.00	Brown and grey slightly sandy silty clay	Unsoaked	25.6	1.83	9.9	3.9
TP02	2.00	Greyish brown and yellowish brown slightly sandy silty clay	Unsoaked	19.1	1.83	10	4.4
TP05	1.00	Greyish brown and bluish grey slightly sandy silty clay with occasional rootlets	Soaked	16.3	1.70	1.2	0.55
TP06	1.00	Greyish brown slightly sandy silty clay	Unsoaked	21.1	1.80	9.3	3.6
TP09	1.70	Yellowish brown slightly sandy gravelly silty clay	Soaked	16.8	1.84	1.1	0.83
TP11	1.50	Yellowish brown slightly sandy slightly gravelly silty clay	Unsoaked	15.5	2.15	25	30
TP13	1.40	Yellowish brown slightly sandy slightly gravelly silty clay	Soaked	21.4	1.42	2.9	0.99
TP16	1.20	Light brown slightly sandy slightly gravelly silty clay	Unsoaked	20.3	1.96	10	7.2
TP19	0.80	Light brown mottled orange slightly sandy slightly gravelly silty clay with rare rootlets	Unsoaked	17.3	1.69	17	7.8
TP19	1.50	Orangish brown slightly gravelly slightly sandy silty clay	Unsoaked	14.6	1.83	10	5.9
TP20	1.80	Light grey and mottled greyish brown slightly sandy silty clay	Soaked	23.3	1.87	1.8	1.4
TP40	1.50	Yellowish brown and greyish brown slightly sandy silty clay	Unsoaked	17.1	1.96	15	10
TP41	1.00	Brown slightly sandy silty clay with occasional rootlets	Unsoaked	19.9	1.52	10	4.9

6.5.2.1 Light Weight Deflectometer Testing

A total of 115 No. Light Weight Deflectometer (LWD) tests were undertaken adjacent to 40 No. trial pit locations containing Residual Soil as presented in Appendix G. The surface modulus (E_0) has been calculated by Geotechnical Engineering Ltd, which ranged from 1.0 MPa to 468.7 MPa, with a lower quartile of 21.5 MPa. It is worth noting the LWD test devices may not be suitable for thicker stiffer pavement foundations (IAN 73/06 Rev 1). The zone of influence for the test typically extends to between 1 and 1.5 times the plate diameter.

The results from the LWD testing were used to calculate the California Bearing Ratio (CBR) values in accordance with CD225a, Equation 2.4, $E = 17.6(CBR)^{0.64}$. However, this equation is only valid for CBR values in the range of 2-12%. Therefore, all CBR values calculated outside of these values have not been included in the following range. The CBR values (within calculated range) averaged a value of 6.3% and a lower quartile of 3.9%. However, it is worth noting that a large amount of test results were outside of this range. Of the 55 No. results

outside the range 37 No. were below 2% and 18 No. were above 12%. Without ignoring these values, the CBR values would average 9.9% with a lower quartile of 1.4%.

Guidance from CD 225 Revision 1 states that when the subgrade surface modulus is lower than 30 MPa (about 2.5% CBR), improvement of the subgrade shall be undertaken. 40 No. tests gave a surface modulus value of under 30MPa, with 23 No. being at ground level. It should be noted that the results of tests carried out at ground level (0.00m) should be used with caution. It is recommended that all surface soils be stripped prior to construction. The remaining tests with a surface modulus under 30MPa, which were not at ground level, were recorded in 11 No. of exploratory holes. These include: TP01, TP06, TP07, TP12, TP14, TP20, TP21, TP25, TP26, TP38 and TP41.

TP06, TP07, TP14 and TP41 are all in close proximity to the streams on site which could be the reason for their low subgrade surface modulus, so further investigation may be required. TP20, TP21, TP25 and TP26 are associated with the golf course and may have been affected by the regular watering. TP01, TP12 and TP38 appear to be located away from any watercourse and therefore could be considered localised soft spots.

CD225 also states that foundations built on a construction subgrade surface modulus of 50 MPa (about 5% CBR) or less have a relatively high risk of structural rutting during construction. This can be prevented through subgrade improvement and/or the use of a capping layer.

Since the results show the majority of the tested soil needs subgrade improvement, it is recommended that further testing is undertaken using equipment complying with BS 1924-2 (2018).

6.5.2.2 Plasticity Index

Equilibrium CBR for the Residual Soil has been estimated from the plasticity index range of 15% to 57%, with an upper quartile of 35%, and material composition in accordance with TRRL Laboratory Report 1132, 1984 'The Structural Design of Bituminous Roads'. A CBR value of 2.5% can be adopted for clay subgrades based on thin construction and 3.0% based on thick construction. However, it should be noted that CD225 requires that the "design subgrade surface modulus shall be determined as being equal to the lower of the short-term subgrade surface modulus and the long-term subgrade surface modulus values."

The CBR value assumes a high water table and good construction conditions. In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

Where silt is predominant at subgrade level, as indicated on some exploratory hole logs and in PSD test results, the TRRL Laboratory Report 1132 indicates a CBR value of 1% or 2% is likely. In this situation subgrade improvement will be required and the potential for frost heave will also need to be taken into account.

Definition of other terms used in TRRL LR1132 are given in section 6.3.2.

6.5.3 Standard Penetration Test

61 No. Standard Penetration Tests (SPT's) were undertaken in the Residual Soil in 19 No. exploratory holes. All the results have been corrected using the energy ratio of the SPT hammer to give an N_{60} value.

In addition Dynamic Probes Super Heavy (DPSH) were undertaken in 16 exploratory hole locations across the site to a depth of 3.9m bgl. The correlation of DPSH blows to SPT N is based on the addition of three sets of blows per 100mm increment to give the 300mm equivalent SPT N value. These have been plotted in Figure 6-6 to allow comparison to SPT N values between 1.2m bgl (at base of hand dug pit) and to a maximum refusal depth of 4.0m bgl.

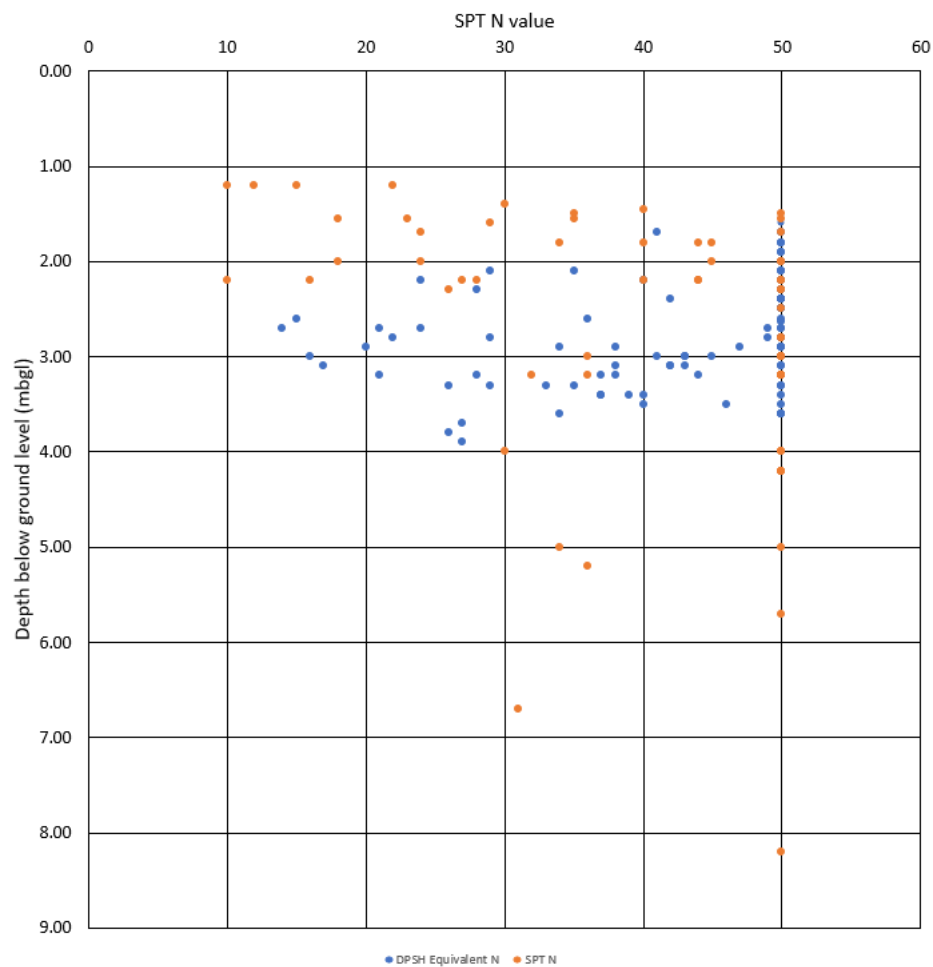


Figure 6-6 Dynamic Probe and SPT N value for Residual Soil

The results of the uncorrected SPT tests are plotted against depth can be seen in Figure 6-7. The N values range between 10 and 50 with the average being 40 and the lower quartile being 32. The N_{60} values range between 14 and 68 with the average being 46 and the lower quartile being 32. The results show that in general above 4m bgl the strength increases with depth.

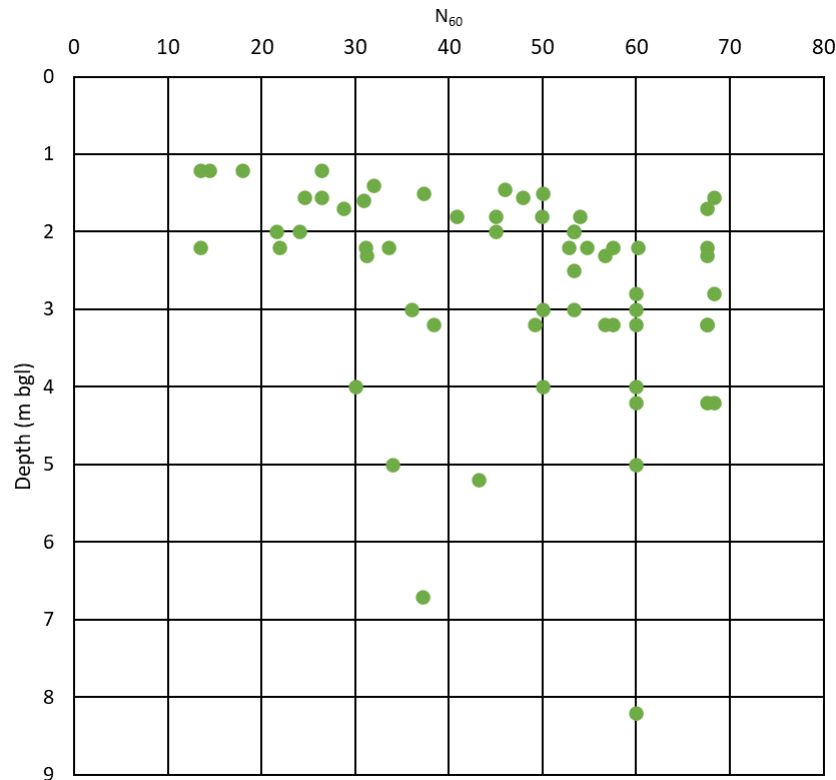


Figure 6-7 Residual Soil N60 Standard Penetration Test Values v depth

6.5.4 Strength

6.5.4.1 Undrained Shear Strength

Based on the SPT results and using the Stroud correlation, $c_u(\text{kPa}) = f_1 \times N_{60}$ (where $f_1=5.0$ for Plasticity Index of 22%), undrained shear strength values have been derived between 68kPa and 342kPa with a lower quartile value of 160kPa. Hand shear vanes and hand penetrometers recorded undrained shear strengths on-site and 12 No. undrained triaxial were carried out in the laboratory to obtain shear strengths ranging between 32kPa and 110kPa.

The range of the results from all the testing from Hand shear Vanes, Pocket Penetrometers, SPT and Undrained Unconsolidated Triaxial testing is presented in Table 6-9 returning undrained shear strengths between 28kPa and 340kPa (excluding residual). The results are presented on Figure 6-8. The results show that in general above 4m bgl the shear strength increases with depth (when residual strength values are excluded).

Table 6-9 Summary of Undrained Shear Strength of Residual Soil

Statistic	SPT N ₆₀ *correlation	Hand Shear Vanes (residual)	Hand Shear Vanes (peak)	Pocket Penetrometer	Undrained Unconsolidated Triaxial
No. Tests	61 (20 Locations)	54 (17 Locations)	54 (17 Locations)	37 (13 Locations)	16 (12 Locations)
Minimum (kPa)	68	6	28	63	32
Maximum (kPa)	342	35	159	225	340
Average (kPa)	231	19	108	187	170
Lower Quartile (kPa)	160	13	85	160	78

*Based on the SPT results and using the Stroud correlation, $c_u(\text{kPa}) = f_1 \times N_{60}$ (where $f_1=5.0$ for Plasticity Index of 29%),

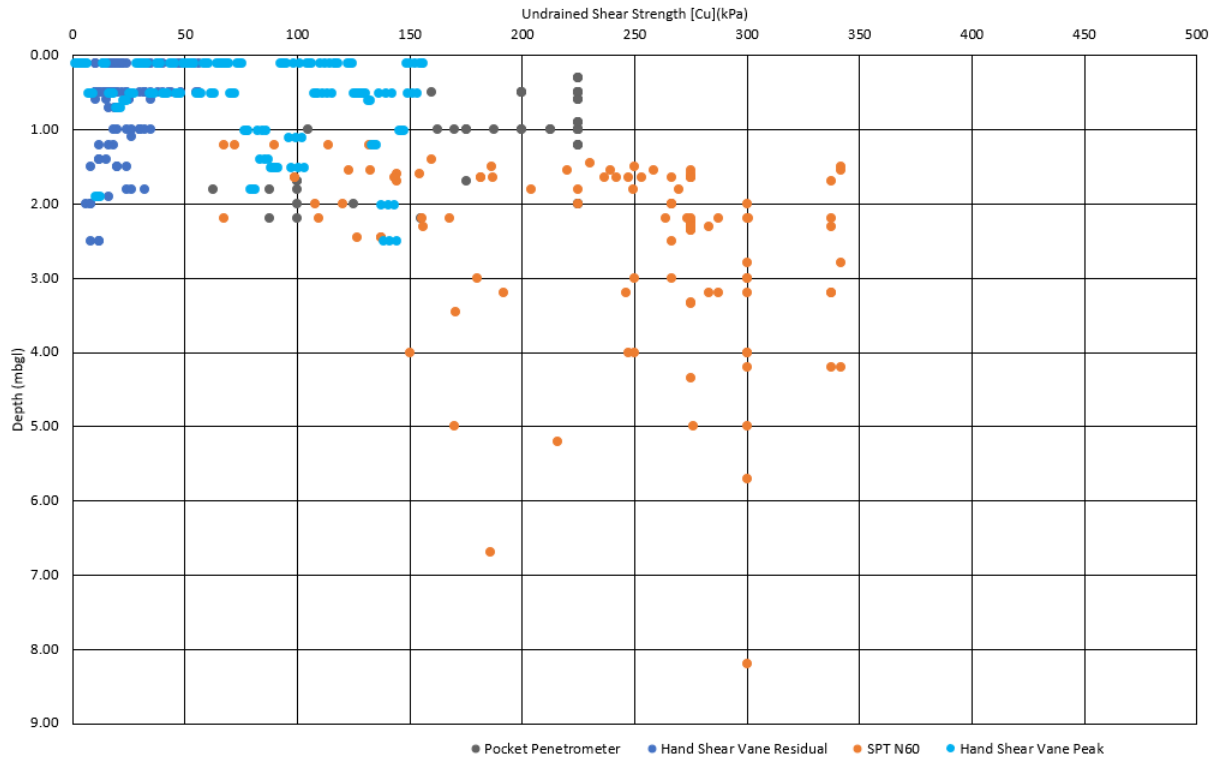


Figure 6-8 Residual Soil Undrained Shear Strength

Residual strength may need to be considered where there is the potential for pre-existing shear surfaces to be present.

6.5.4.2 Drained Shear Strength

For drained shear strength of cohesive Residual Soil the proposed correlation by Santamarina et al., (2003) has been used to estimate the effective constant volume angle of shearing resistance ϕ'_{cv} . This is based on the returned plasticity indices (I_p) of the Residual Soil from Atterberg Limit testing summarised in Section 6.5.1/ The following formula was used;

$$\phi'_{cv} = 42^\circ - 12.5 \log_{10}(I_p)$$

The Plasticity Index results ranged between 15% and 57% with an average of 29%, resulting in the correlated ϕ'_{cv} between 20° to 27° with an average of 24° . Two samples returned I_p values greater than 50% correlating to a ϕ'_{cv} of 20° .

6.5.4.3 Stiffness

The Jamiolkowski et al. (1979) correlation can be used to derive the undrained Young's Modulus where:

$$E_u = 300 * C_u$$

Which gives an undrained Young's Modulus ranging between 18 MPa and 78 MPa, with an average of 57 MPa and lower quartile of 42 MPa based on the undrained shear strength results ranging between 68 kPa and 288 kPa (excluding SPT Refusal where $N > 50$).

Assuming linear elasticity, the drained Young's Modulus can be estimated according to the following formula where ν' is estimated to be 0.25.

$$E' = E_u * 2 \frac{(1 + \nu')}{3}$$

Resulting in values ranging between 17 MPa and 72 MPa, with an average of 53 MPa and lower quartile of 39 MPa based on the undrained shear strength results ranging between 68 kPa and 288 kPa.

6.5.5 Compaction

Compaction tests (2.5kg) were carried out on 12 No. samples of Residual Soil. The results are displayed in Table 6-10. The results show that the average optimum moisture content is 24%, which is 2% higher than the average natural moisture content of 22%.

Table 6-10 Dry Density/ Moisture Content Residual Soil

Hole ID and depth (m bgl)	Description	Natural Moisture Content (NMC) %	Maximum Dry Density (Mg/m ³)	Optimum Moisture Content (%)
TP01_2	Brown and grey slightly sandy silty clay	25	1.50	27
TP04_1.8	Greyish brown slightly gravelly slightly sandy silty clay	19	1.63	22
TP06_1	Greyish brown slightly sandy silty clay	23	1.56	24
TP07_1.6	Grey slightly sandy silty clay	22	1.53	26
TP13_1.4	Yellowish brown slightly sandy slightly gravelly silty clay	22	1.55	25
TP16_1.2	Light brown slightly sandy slightly gravelly silty clay	20	1.65	21
TP20_1.8	Light grey mottled greyish brown slightly sandy silty clay	23	1.56	23
TP22_0.5	Light grey slightly sandy silty clay	22	1.46	28
TP23_1.5	Light grey slightly gravelly slightly sandy silty clay	16	1.65	21
TP33_0.5	Light greyish brown slightly sandy slightly gravelly silty clay	22	1.54	24
TP36_2	Yellowish brown slightly sandy slightly gravelly silty clay	18	1.66	20
TP37_1.7	Orangish brown and bluish grey slightly gravelly slightly sandy silty clay	25	1.54	25

6.5.6 Compressibility

10 No. one dimensional consolidation tests were undertaken in the Residual Soil. The samples were loaded to a level beyond their in-situ stress conditions, after which an unloading-reloading cycle was applied, followed by another stress increment. The coefficient of volume compressibility, M_v , and coefficient of consolidation, C_v , measured during oedometer testing is presented in Table 6-11. According to Tomlinson (2001), the Residual Soil has low to medium compressibility characteristics.

Table 6-11 Residual Soil Consolidation Test Results

Hole ID_Test Depth	Stress (kPa)	Void Ratio	Volume Compressibility Coefficient (m_v) (m ² /MN)	Coefficient of Consolidation (c_v) (m ² /year)
BH08_1.2	60	0.647		6.3
	120	0.639	0.13	7.3
	40	0.627	0.11	
	60	0.641	0.18	5.3
	80	0.635	0.081	3.3
	160	0.632	0.11	8.1
	40	0.619	0.095	
BH13_1.2	60	0.692	0.22	14
	20	0.67	0.11	
	30	0.677	0.37	290

Hole ID_Test Depth	Stress (kPa)	Void Ratio	Volume Compressibility Coefficient (m_v) (m^2/MN)	Coefficient of Consolidation (c_v) ($m^2/year$)
BH16_1.2	40	0.671	-0.0053*	200
	80	0.671	0.14	17
	20	0.662	0.088	
	60	0.515		
	120	0.5	0.091	5.7
	40	0.492	0.11	
	60	0.504	0.25	15
	80	0.497	0.036	8.7
	160	0.496	0.095	6
DS01_2	40	0.484	0.093	
	120	0.746	0.13	73
	40	0.719	0.063	
	60	0.727	0.023	1.8
	80	0.727	0.056	2
	160	0.725	0.094	3.5
DS02_3	40	0.712	0.055	
	180	0.72		
	360	0.712	0.042	12
	120	0.7	0.072	
	160	0.729	0.013	3.3
	240	0.728	0.081	1.3
	480	0.717	0.075	0.84
DS03_1.2	120	0.686	0.061	
	60	0.558		
	120	0.564	0.053	17
	40	0.559	0.16	
	60	0.579	0.37	17
	80	0.567	0.042	13
	160	0.566	0.059	13
DS07_3	40	0.558	0.1	
	180	0.613		
	360	0.573	0.061	7.7
	120	0.555	0.049	
	180	0.574	0.03	4.2
	240	0.571	0.054	4.9
	480	0.566	0.057	4.7
	120	0.544	0.042	
DS13_1.2	60	0.565		
	120	0.554	0.086	40
	40	0.546	0.1	
	60	0.559	0.097	15
	80	0.556	0.067	26
	160	0.554	0.096	24
	40	0.542	0.078	
DS15_1.2	60	0.477		
	120	0.456	0.057	21

Hole ID_Test Depth	Stress (kPa)	Void Ratio	Volume Compressibility Coefficient (m_v) (m^2/MN)	Coefficient of Consolidation (c_v) ($m^2/year$)
DS16_1.2	40	0.451	0.067	
	50	0.459	0.11	35
	60	0.457	0.032	50
	120	0.457	0.063	14
	40	0.451	0.058	
	60	0.632		
	120	0.633		
	240	0.633	0.032	5.3
	80	0.627	0.024	
	120	0.633	0.09	6.1
DS16_1.2	160	0.627	-0.0037*	6.6
	320	0.627	0.014	6.1
	80	0.624	0.014	

- Note: the consolidation testing reports cell pressures higher than originally scheduled, as selected by the laboratory upon receiving the sample.

* the values indicated as negative are likely to be due to the small change in stress allowing swelling of the sample to take place

Figure 6-9 presents a plot of void ratio versus effective stress for the oedometer tests.

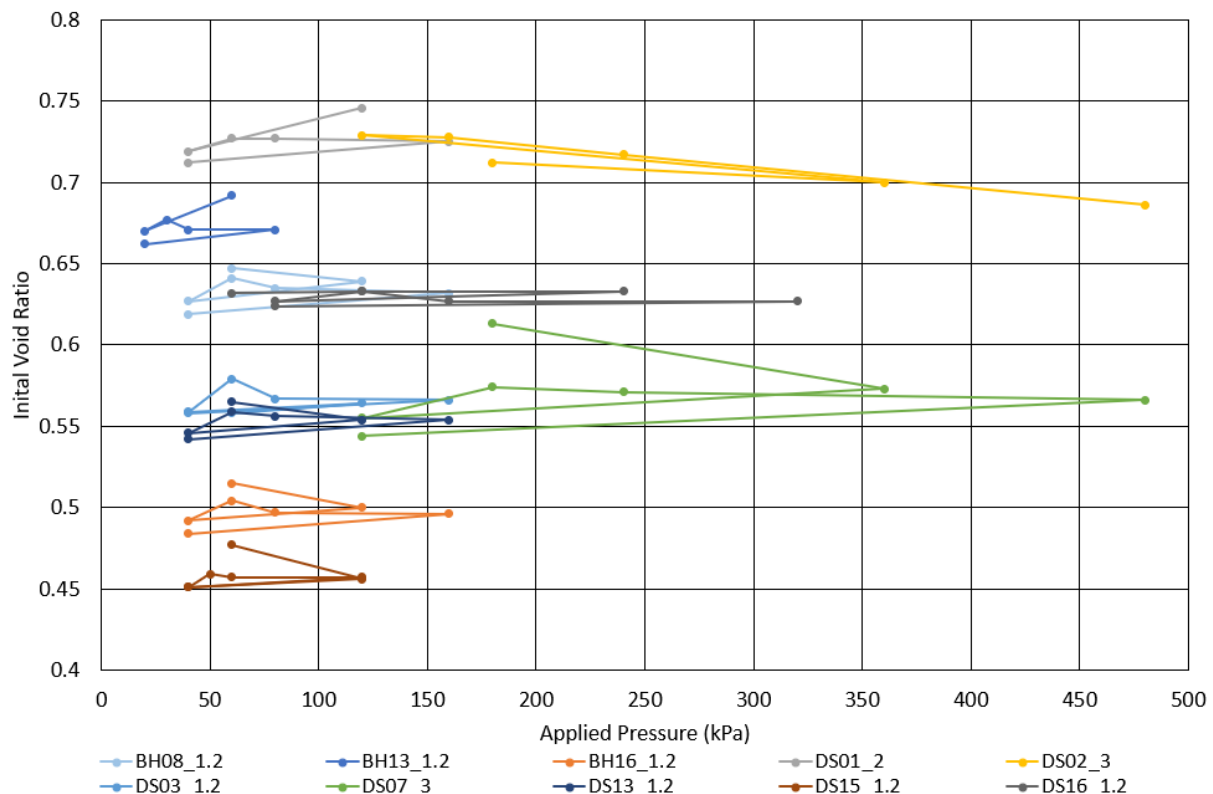


Figure 6-9 Void Ratio vs Effective Stress from compressibility tests Residual Soil

Figure 6-10 presents a plot of co-efficient of volume change (m_v) versus effective stress for each oedometer test.

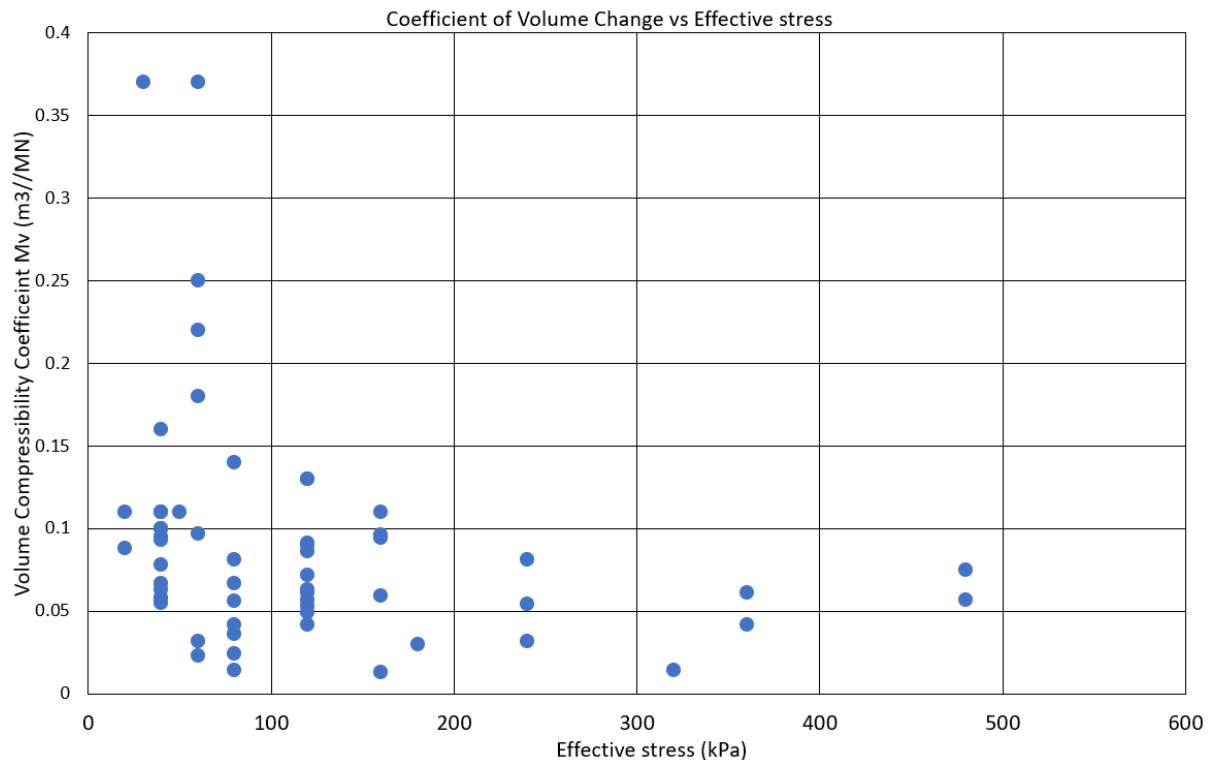


Figure 6-10 Coefficient of Volume Change vs. Effective Stress Residual Soil

6.5.7 Permeability

The permeability in vertical direction (K_v) has been derived from each oedometer test using the following equation.

$$K_v = c_v \cdot \gamma_w \cdot m_v$$

Where:

- c_v = coefficient of consolidation
- m_v = coefficient of volume compressibility
- γ_w = unit weight of water taken as 9.81 kN/m³

Permeabilities between 9.19×10^{-6} m/s and 9.74×10^{-11} m/s were estimated from the coefficients of consolidation derived from both the log-fitting methods. Anisotropy within the Residual Soil may result in higher permeabilities in the horizontal direction.

6.6 Weald Clay Formation- Grades I to II

The Weald Clay Formation was encountered in 47 locations across the Site, from 0.7m bgl to 9.3m bgl. The depth to base was not encountered in any exploratory locations. The depth to top to the Weald Clay is presented in Figure 6-11.

The Weald Clay was described as extremely weak to weak grey and light grey thinly and thickly interlaminated mudstone and siltstone, fractures are sub-horizontal closely and medium spaced planar smooth. It is frequently described as weak grey and light grey siltstone with extremely closely to closely spaced thin laminae to very thin beds of mudstone and sandstone. Bedding fractures are described as sub-horizontal closely and medium space planar.

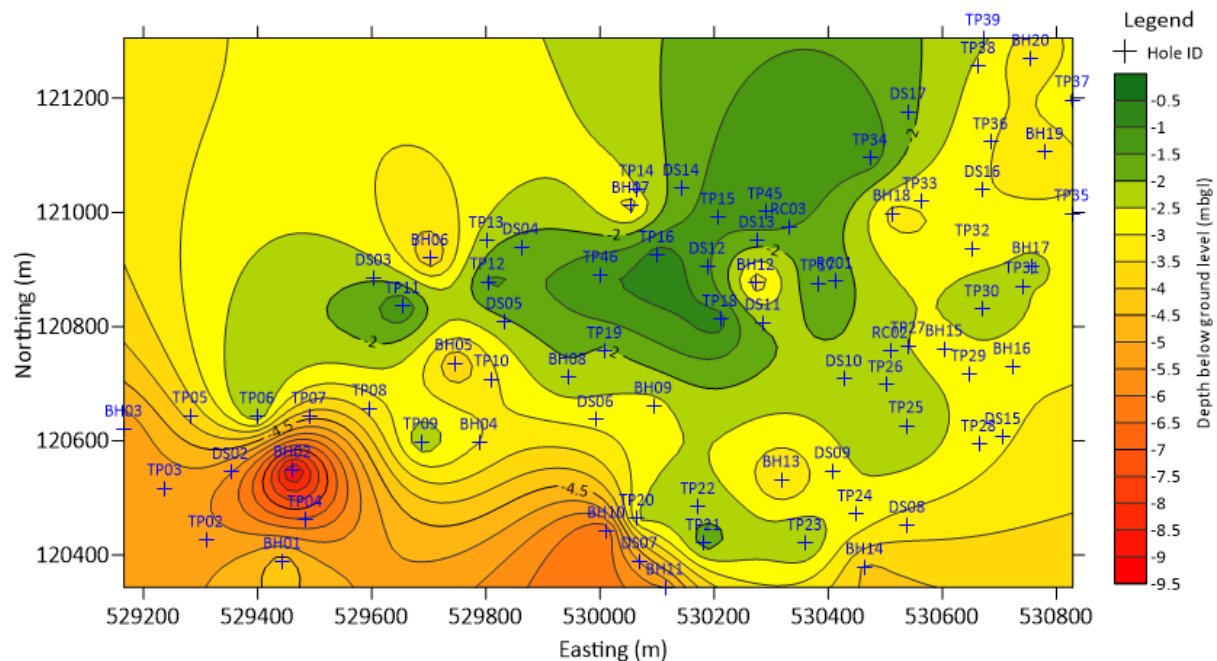


Figure 6-11 Depth to Top of Weald Clay

(This figure has been generated using Golden Software: Surfer to interpolate a raster surface from a series of points. The mapping generated should be used with caution especially where the density of data points is limited)

In addition, slightly weathered to unweathered Weald Clay was encountered in five boreholes (BH03, BH05, BH07, BH16 and BH17). Within this Weald Clay as beds of medium strong mudstone, sandstone and siltstone were encountered within the slightly weathered Weald Clay. These bands were described as a weak becoming medium strong, light brown to dark grey mudstone in BH03 and BH07, with very thin to thin beds of medium strong light brownish grey calcareous mudstone between 19.10m and 20.0m bgl with a thickness of 0.65m to 0.9m. In BH05 a 0.35m thick band of medium strong grey and brown fine sandstone was note from 15.50m to 15.85m bgl. In BH16 and BH17 bands of medium strong light grey to greyish brown siltstone were encountered ranging between 0.15m and 0.45m in thickness between 8.60m bgl and 17.70m bgl.

Summary of parameters relating to the material behaving as a rock have also been provided for the rock mass, whilst some soil testing has been undertaken on suitable samples recovered as gravel they are not representative of the material properties in situ and therefore have not been presented but can be reviewed in the Factual Report in Appendix C.

The following tests were undertaken in the Weald Clay:

- 226 No. Standard Penetration Tests (SPT)
- 22 No. Uniaxial Compressive Strength Tests (UCS)
- 116 No. Point Load Index Tests (PLT)
- 4 No. Lightweight Deflectometers

6.6.1 Surface Modulus and California Bearing Ratio

Where Partially Weathered Weald Clay was encountered in the absence of Residual Soil, below Topsoil CBR and Subgrade Modulus testing has been undertaken to a maximum of 2m bgl.

6.6.1.1 Light Weight Deflectometer Testing

A total of 4 No. Light Weight Deflectometer (LWD) tests were undertaken adjacent to 4 No. trial pit locations containing Weald Clay at 1.0m depth as presented in Appendix G. The surface modulus (E_0) has been calculated by Geotechnical Engineering Ltd, which range from 111.0 MPa to 304.0 MPa, with a lower quartile of 132.8MPa. TP46 at 1.0m bgl was not included within this range since the test produced a subgrade surface modulus value of 22.7MPa and a CBR value of 1.48%. This was considered an anomaly because higher results are expected since it should be acting as a rock. Where such soft spots are encountered during construction there extent should be verified and the soft soil excavated and replaced with suitably compacted fill.

The results from the LWD testing were used to calculate the California Bearing Ratio (CBR) values in accordance with CD225, Equation 2.4, $E = 17.6(CBR)^{0.64}$. However, this equation is only valid for CBR values in the range of 2-12%. All results were higher than 12%, apart from the anomalous TP46 test, therefore the CBR values could not be considered.

6.6.1.2 Plasticity Index

Equilibrium CBR for the Weald Clay has been estimated where fine soil dominated from the plasticity index range of 20% to 35%, with an upper quartile of 28%, and soil composition in accordance with TRRL Laboratory Report 1132, 1984 'The Structural Design of Bituminous Roads'. A CBR value of 3.5% can be adopted based on thin construction and 5.0% based on thick construction. The CBR value assumes a high-water table and good construction conditions. In selecting the Design CBR value for the subgrade, consideration must be given to the likely moisture conditions applying during construction.

Definition of other terms used in TRRL LR1132 are given in section 6.3.2.

6.6.2 Strength

6.6.2.1 Standard Penetration Test

226 No. Standard Penetration Tests (SPT) were undertaken in the slightly weathered to unweathered Weald Clay. The results have been corrected using the energy ratio of the SPT hammer to give an N_{60} value. A minimum SPT N value of 28 was recorded within the Weathered Weald Clay, the majority reached refusal. The N values range between 28 and 50 with the average being 50 and the lower quartile being 50. The N_{60} values range between 34 and 68 with the average being 58 and the lower quartile being 53. The four results where the SPT did not refuse were in rock described as extremely weak mudstone corresponding to a UCS of 0.6-1.0 MPa as indicated in BS5930.

6.6.2.2 Unconfined Compressive Strength and Point Load Test

A total of 116 point load tests were carried out on samples taken from the Weald Clay Formation to determine the strength index values, reported as Is_{50} . All tests were undertaken on both axial and diametral samples. The testing was undertaken on samples described as mudstone, sandstone and siltstone. A correlation between the rock description and strength was identified. The results of the testing as presented in Table 6-12 and Figure 6-12 showed that generally axial test results are higher than diametral results and there is an increase in strength with depth.

Table 6-12 Point Load Axial and Diametral Results

Orientation	Range	Size corrected load Is_{50} (MPa)	
		Average	Lower Quartile
Axial	0.01-0.51	0.17	0.09
Diametral	0.01-0.31	0.13	0.07

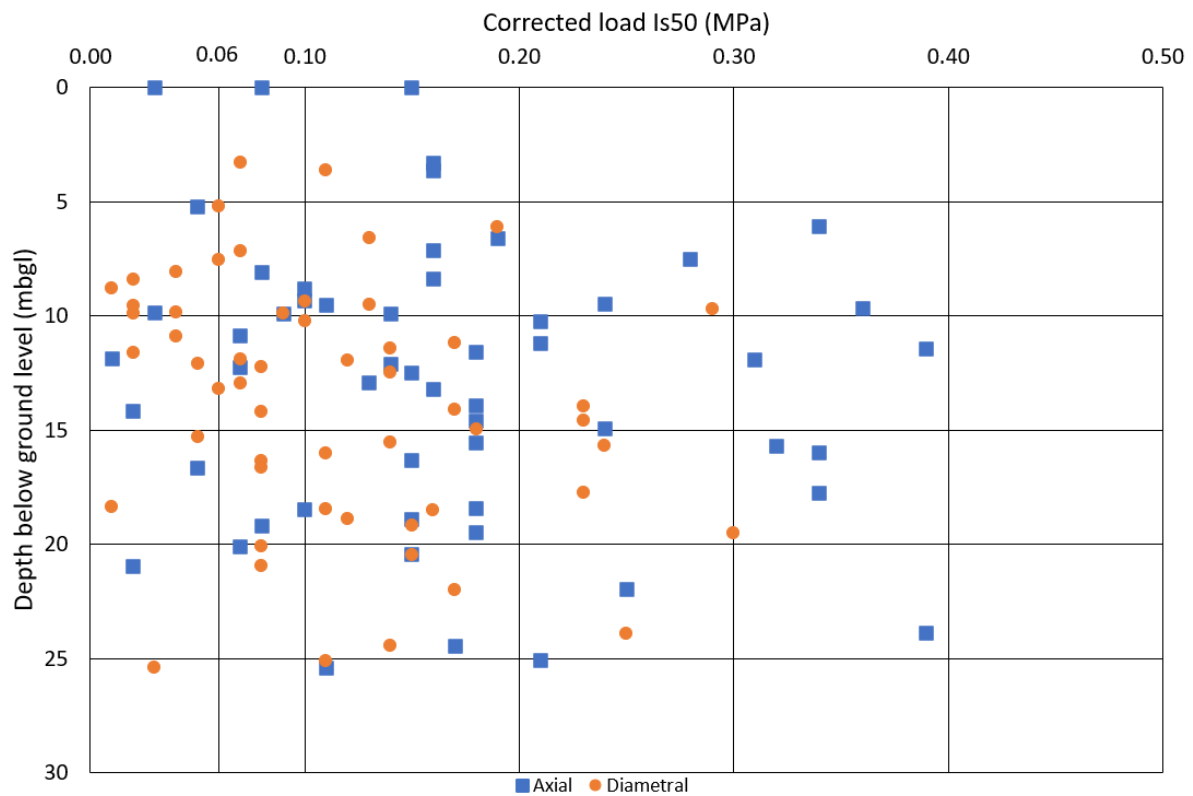


Figure 6-12 Weald Clay I_{s50} Results

22 No. UCS tests were carried out within the Weald Clay. The results varied between 0.10 MPa and 3.75 MPa with an average of 1.16 MPa and lower quartile of 0.34 MPa. The results of the testing can be reviewed in Figure 6-13 along with PLT results converted to UCS. The factors applied are based on site specific correlations between PLT and UCS testing on similar sample depths and material description, as outlined in Table 6-13. It should be noted that no UCS tests and only one PLT was carried out on sandstone and as such a factor of 20 based on Norbury 1986 has been used.

Table 6-13 Correlations between PLT and UCS

Material	No. Tests	Correlation Factor
Mudstone	19	14
Siltstone	2	29
Sandstone	1	20 (based on Norbury 1986)

The preferential general failure mechanism from the UCS testing was shown as axial cleavage cataclasis.

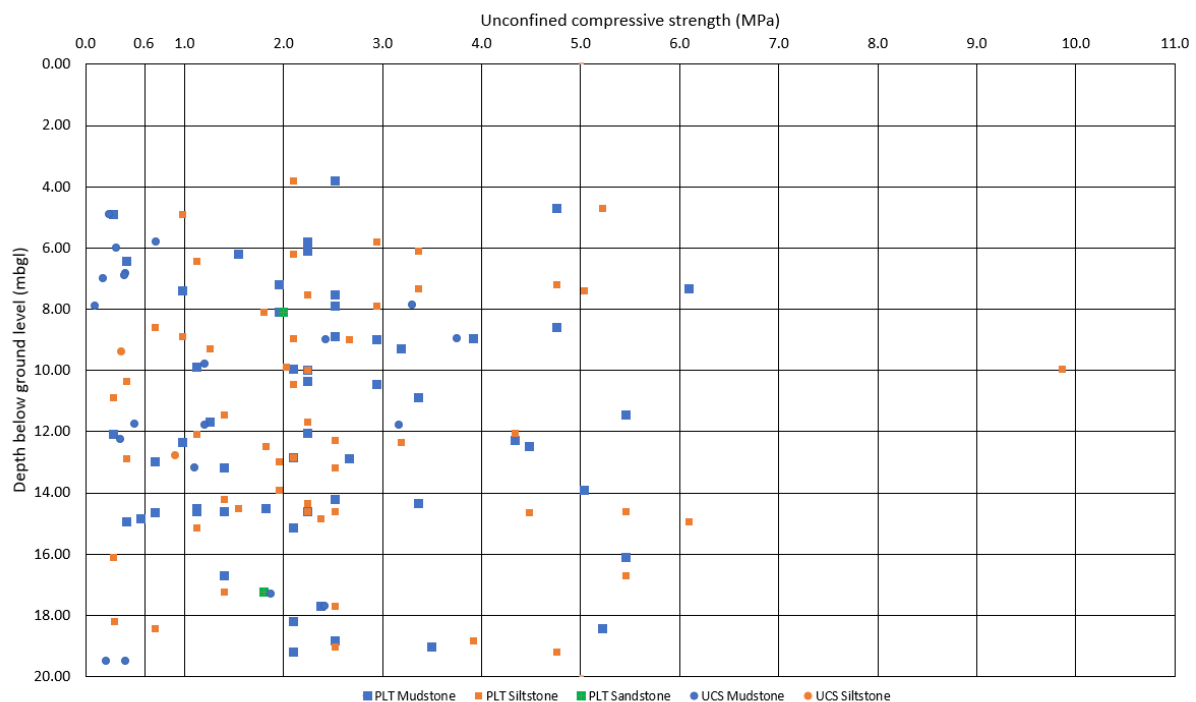


Figure 6-13 UCS Weald Clay results

The results shown in Figure 6-13 indicate that the rock is based on BS 5930 predominantly extremely weak and very weak (0.6MPa to 5MPa) with occasional results suggesting that the rock is weak (5 to 25MPa). A significant number of the results are below 0.6MPa indicating a strength less than extremely weak. The designer should select an unconfined compressive strength profile appropriate to the structure being designed and based on both borehole descriptions and test data local to the structure.

6.6.3 Deformation Modulus of Rock Mass

The parameters used as inputs to determine the Intact Modulus (E_i) of the mudstone are summarised below.

- Geological Strength Index (GSI) = 30 - Based on structure and surface conditions of fracture in rock with bedding planes and laminated zones noted.
- $M_i = 4$ (Based on typical values for 'Claystone') and 12 (Based on typical values for Sandstone)

The criteria utilises uniaxial compressive strength for intact rock (σ_{ci}) and the modulus ratio (MR), a ratio of mass to intact modulus (E_m/E_i).

The following formula was applied using RocScience RocLab;

$$E_i = MR\sigma_{ci}$$

Where:

- σ_{ci} was based on the UCS and PLT testing
- Modulus ratio (MR) = 250 (Based on typical values for Mudstone (claystone) and Siltstone) and 275 (Sandstone)

Table 6-14 Intact Modulus: Weald Clay (Grade I and II)

Strength Description	UCS (MPa)	Mudstone/ Siltstone	Sandstone
		E_i (MPa)	E_i (MPa)
Extremely Weak	0.6-1.0	150-250	165-275
Very Weak	1.0-5.0	250-1250	275-1375
Weak	5.0-25.0	1250-6250	1375-6875
Medium Strong	25-50	6250-12500	6875-13750

6.6.4 Rock Quality Designation (RQD)

Rock Quality Designation (RQD) values were derived from all solid core recovered from the rotary core boreholes within the GEL 2023 GI. The frequency of RQD is presented in

Figure 6-14 where RQD improves with depth.

The average fracture spacing (from If fracture spacing recorded on the borehole logs) with depth is presented on Figure 6-6-15.

The widest fracture spacing occurred in; BH17 at 12.0m bgl in weak grey mudstone where fractures are 20 degrees and 80 degrees planar smooth, BH20 at 11.50m bgl in very weak thinly laminated mudstone, fractures are 50 degrees widely spaced undulating smooth and BH08 at 14.20m bgl within a weak thinly and thickly laminated siltstone where fractures are sub horizontal to 20 degrees widely spaced, planar and smooth.

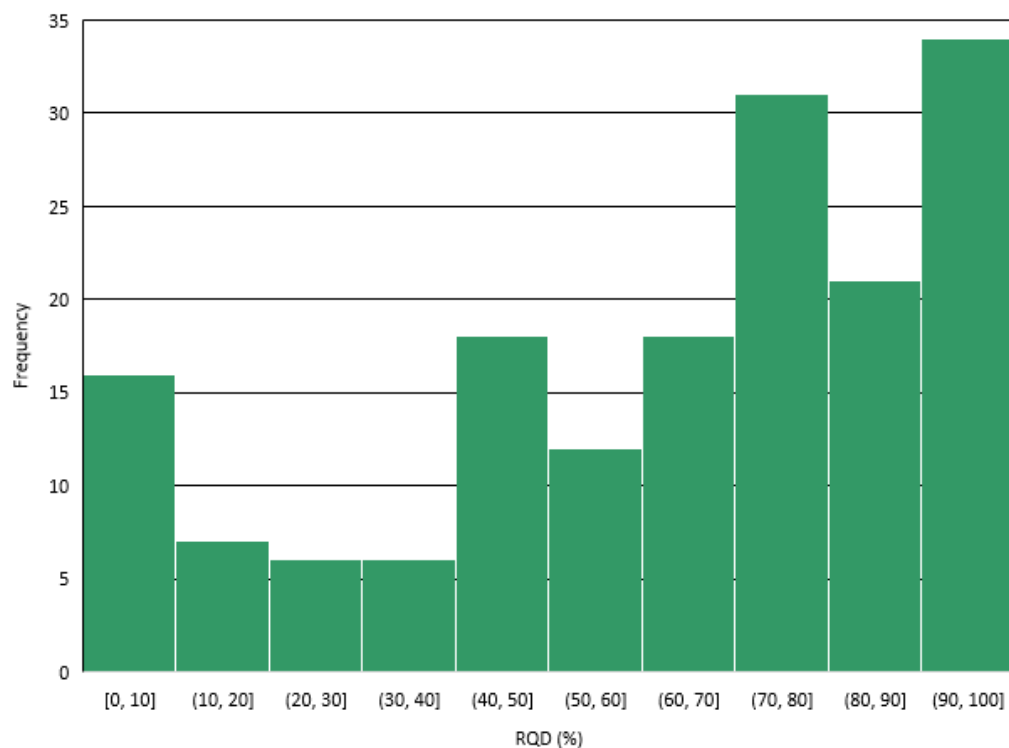


Figure 6-14 RQD Index for Weald Clay

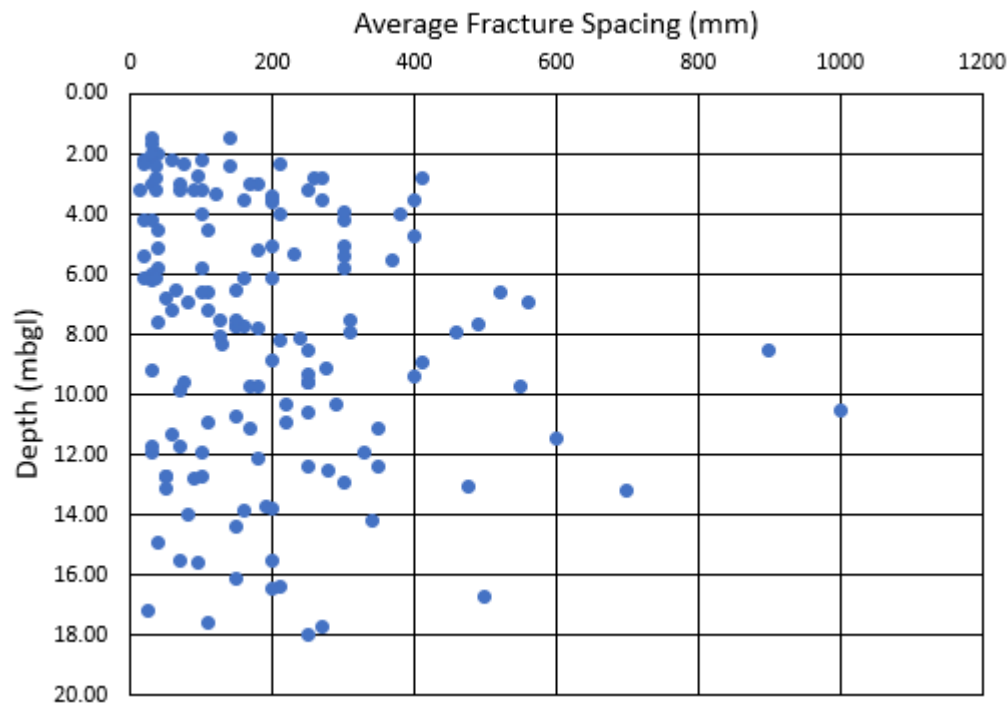


Figure 6-6-15 Average Fracture Spacing (lf) with Depth

6.7 Soil and Groundwater Chemistry (Sulphates)

The results of site-specific ground aggressivity testing have been reviewed against the procedure outlined in BRE Special Digest 1:2005 Concrete in aggressive ground, to determine the Design Sulphate (DS) and Aggressive Chemical Environment for Concrete (ACEC) classes for the strata beneath the site. Brownfield conditions have been assumed for all strata. The DS and ACEC class were based on the 2:1 water soluble sulphate since the amount of oxidisable sulphides were not greater than 0.3% SO₄ in a significant number of samples of any of the strata.

Table 6-15 summarises the DS and ACEC classes to be adopted for the design of buried concrete.

Table 6-15 Summary of BRE SD1 Assessment

Sample	Property	No. of Tests	Results Range	Characteristic value	DS Class	ACEC Class
Made Ground	2:1 Water soluble sulphates (SO ₄ mg/l)	3	10-250	250	DS-1	AC-2z
	Total Potential Sulphates (SO ₄ %)		0.09-0.16	0.16		
	pH		6.3-7.9	6.3		
Alluvium	2:1 Water soluble sulphates (SO ₄ mg/l)	2	17-53	53	DS-1	AC-2z
	Total Potential Sulphates (SO ₄ %)		0.09-0.25	0.25		
	pH		6.1-6.9	6.1		
Residual Soil	2:1 Water soluble sulphates (SO ₄ mg/l)	36	10-1600	290	DS-2	AC-3z
	Total Potential Sulphates (SO ₄ %)		0.01-1.00	0.58		
	pH		5.1-8.4	5.6		
Weald Clay	2:1 Water soluble sulphates (SO ₄ mg/l)	19	10-160	105	DS-1	AC-2

Sample	Property	No. of Tests	Results Range	Characteristic value	DS Class	ACEC Class
Groundwater*	Total Potential Sulphates (SO ₄ %)	32	0.03-0.42	0.33	DS-2	AC-2
	pH		5.6-9.3	6.0		
	Sulphates (SO ₄ mg/l)		7.7-910 (Weald Clay)	1400		
	pH		42-1400 (Residual Soil)	6.6		
			6.6-8.3 (Weald Clay)			
			6.8-11.4 (Residual Soil)			

*Groundwater samples were only undertaken within samples of Residual Soil and Weald Clay

It should be noted that BRE SD1 lists the Weald Clay as a formation that is known to contain pyrite. It also mentions that the Weald Clay is one of the formations likely to have substantial sulphate concentrations. The DS-1 and AC-2 classes given above could potentially underestimate the soil aggressivity where pyrite content is high. Selenite (produced by weathering of pyrite) was noted within Residual Soil and Partially Weathered Weald Clay at four exploratory locations; TP01, TP04, TP05 and TP41. It is possible it was present in additional locations on site.

6.8 Road Cores

Three road cores (RC01 to RC03) were carried out within Cuckfield Road to confirm the road construction at these locations. Tarmacadam was found from surface for between 0.13m and 0.15m. In RC02 the tarmacadam was underlain by 0.2m of concrete. All locations had Made Ground underlying the road construction comprising of sands and gravel. The Made Ground was found to be to depths of between 0.6m bgl and 0.75m bgl with residual soil of Weald Clay in the base of the excavations.

6.9 Soakaway Testing

A total of 16 number of soakaway tests were carried out in trial pits (TP08, TP10, TP11, TP15, TP17 to TP19, TP22, TP24, TP31, TP32, TP34, TP39 to TP41 and TP46). The testing was carried out in general accordance with BRE 365. All the testing was unsuccessful, and no infiltration rates were recorded due to very slow water ingress regardless of underlying geology in Residual Soil or Partially Weathered Weald Clay.

6.10 Summary of Derived Geotechnical Parameters

A summary of geotechnical parameters for the Made Ground, Alluvium, Residual Soil and Weald Clay is provided in the Table below. The designer should select an appropriate ground profile and parameters for the structure being designed and based on both exploratory hole descriptions and test data local to the structure.

Table 6-16 Summary of Derived Geotechnical Parameters

Parameter	Unit	Topsoil	Made Ground	Alluvium	Residual Soil (Grades V & VI)	Partially Weathered to Unweathered Weald Clay (Grades I to II)	Justification
Uncorrected SPT N Value	Blows/300mm	-	-	0-1	10-50	-	In situ strength testing
SPT 'N60'	-	-	-	0-1	14-68	-	In situ strength testing
Natural Moisture Content (MC)	%	-	17-26	37 & 68	11-60 (AV22, LQ16)	-	Classification laboratory testing
Plastic Limit (PL)	%	-	22-25	22 & 26	19-33 (AV25, LQ24)	-	Classification laboratory testing
Liquid Limit (LL)	%	-	42-51	40 & 47	40-90 (AV54, LQ46)	-	Classification laboratory testing
Plasticity Index (PI)	%	-	20-29	18 & 21	15-56 (AV29, LQ22)	-	Classification laboratory testing
Modified Plasticity Index (I _p)	%	-	16-18	18 & 21	8-56 (AV26, LQ20)	-	Classification laboratory testing
Unit Weight of Material	kN/m ³	-	17-19	18	19	-	Classification laboratory testing and Table 1 and 2 BS8002
Undrained Shear Strength (Cu)	kPa	-	162-225 [PP] >150 [HV]	0 -6	68-342 (AV231, LQ160) [SPTN60] 63-225 (AV187, LQ160) [PP] 32-240 (AV170, LQ78) [Triaxial UU]	-	In situ strength testing and laboratory undrained unconsolidated Triaxial testing

Parameter	Unit	Topsoil	Made Ground	Alluvium	Residual Soil (Grades V & VI)	Partially Weathered to Unweathered Weald Clay (Grades I to II)	Justification
Effective Strength , angle of constant shearing resistance (ϕ'_{cv})	°	-	24-26 (AV25)	22 & 26	20-27 (AV24)	-	Santamarina et al., (2003)
Drained Stiffness	MPa	-	-	0-2	17-72 (AV53, LQ39)	-	Jamiolkowski et al., (1979)
Undrained Stiffness	MPa	-	45-56	0-2	18-78 (AV57, LQ42)	-	Jamiolkowski et al. (1979)
CBR	%	-	2.8-9.6 (AV3.4) [LWD] 3.5-5.0 [Lab PI]	-	3.2-14.6 [LWD] 0.96-25 Top , 0.55-30 Base [Lab CBR] 2.5-3.0 [Lab PI]	-	Lightweight Deflectometer using TRRL Laboratory Report 1132, Laboratory Plasticity Index Testing and Laboratory Soaked and Unsoaked CBR
Permeability (kv)	m/s	-	-	1.88 x10 ⁻¹⁰ - 8.46 x10 ⁻¹³	3.33 x10 ⁻⁸ - 9.74 x10 ⁻¹¹	-	Consolidation Testing
Volume Compressibility Coefficient (Mv)	m ² /MN	-	-	0.0015-0.72	0.013 – 0.37	-	Tomlinson (2001)
Optimum Moisture Content	%	-	-	-	20-27 (AV24)	-	Compaction Testing
Maximum Modified Dry Density	Mg/m ³	-	-	-	1.46-1.66 (AV1.57)	-	Compaction Testing
Unconfined Compressive Strength (UCS)	MPa	-	-	-	-	0.1 – 3.75 (AV1.16, LQ0.34) (UCS)	UCS Testing
Point Load Testing (PLT)	MPa	-	-	-	-	0.01-0.51 (Axial) 0.01-0.31 (Diametral)	Point Load Testing

Parameter	Unit	Topsoil	Made Ground	Alluvium	Residual Soil (Grades V & VI)	Partially Weathered to Unweathered Weald Clay (Grades I to II)	Justification
Intact Modulus(Ei) – mudstone/siltstone	MPa	-	-	-	-	Extremely Weak 150-275 Very Weak 250-1375 Weak 1250-6875 Medium Strong 6250-13750	Rocscience Roclab

AV – average; LQ – lower quartile

7. Engineering Recommendations

7.1 Soakaway Design

The results of all infiltration testing indicated that the ground conditions are not suitable for infiltration due to the limited infiltration achieved during the testing.

7.2 Shallow Foundations and Earthworks

Information on the final design and loadings of structures is not yet available. For typical house construction of 2-3 storeys, with low magnitude loads, shallow foundations are likely to be suitable. For more heavily loaded developments such as apartment blocks, and multistorey business infrastructure piles may be required. The depth to groundwater will need to be considered in the foundation design.

The depth of the foundations in shrinkable soils is dependent on the shrinkage potential of the soil and the presence of any existing, recently removed or proposed vegetation. Based on the classification testing the Residual Soil at the site is indicated to be of medium and high volume change potential for which a minimum foundation depth of 1.0m is recommended in the NHBC standards outside the no tree planting zone or the zone where any existing trees may have an influence. Where foundations will be within the zone of influence of vegetation the founding depth will need to be increased in accordance with published standards (e.g. NHBC).

The exploratory holes in Weald Clay indicate the ground may be relatively stable in the short term in open excavations. All excavations requiring manned entry should be battered well back or provided with close/continuous support. The exploratory holes also indicate that groundwater seepage/flow should be expected as shallow as 1.3m bgl with ongoing monitoring returning results at surface.

Ground improvement may be required in areas of land raising to control excessive post construction settlements. The need for ground improvement would need to be assessed when further detailed design of the proposed works become available.

7.3 Deep Foundations

It is likely that deep foundations such as piling will be required for multi-occupation buildings such as apartment blocks. Pile foundations are also likely to be required for commercial buildings located to the west at Western Park.

7.4 Road Pavement

The estimated minimum range of equilibrium CBR values for soils and groundwater conditions described above, under a completed pavement, is based on TRL LR1132. The recommended sub-grade soil CBR value for road pavement design is presented per tested strata in section 6 with a summary included in Table 6-16. The values assume that during construction the formation level will be carefully compacted, and any soft spots or silt dug out and replaced by a compacted suitable granular fill and that continuous monitoring will be undertaken during construction to ensure that the insitu CBR values is always higher than the design. The soaked CBR lab test results indicate that CBR values can be less than 2% if the formation is allowed to become saturated. Drainage may need to be considered to prevent the formation becoming saturated.

The sub-grade soils can be regarded as potentially frost -susceptible, due to description of Residual Soil as silt and weathered Siltstone within the Weald Clay after the criteria given in Manual of Contract Documents for Highway works Series 700. Where the sub-grade is frost-suspectable the thickness of subbase must be sufficient to give a total thickness of non-frost suspectable pavement over the soil of not less than 450mm.

7.5 Design of Buried Concrete

Assessment of the results of pH and sulphate testing indicates that concrete in contact with the soils will need to be designed for Design Sulphate Class of DS-2 and an ACEC class of AC-3z. Further investigation may be needed due to the lack of results in certain strata.

8. Geo-environmental Assessment

This section presents a Tier 1 and Tier 2 contaminated land assessment in general accordance with Land Contamination Risk Management (LCRM) guidance, following the ground investigation at Northern Arc – Brookleigh, Phases 2, 3 and 4.

This assessment aims to identify potential risks and constraints arising from land contamination. Both past and current potentially contaminative land uses, along with data obtained during the GI, have been considered. Note localised areas of contamination may not have been identified due to the distribution of the exploratory locations and the limited coverage of the GI works.

8.1 Preliminary Conceptual site Model and Risk Assessment

A preliminary conceptual site model (CSM) has been developed for the site considering its proposed end use (residential properties, community developments and public open spaces). The CSM is based on the environmental setting of the site and a review of current and historical development on-site (and in the immediate surroundings).

8.1.1 Sources

8.1.1.1 On-site Sources

Historical mapping (sourced from an Envirocheck report, available to view as Appendix D & Appendix E) shows that the wider development site was largely occupied by open agricultural land farm buildings since earliest available historical mapping (published 1899) with little to no development. The current site layout is also largely agricultural, with limited development since the earliest historical mapping.

Based on historical and existing land uses, the following potential sources of contamination have been identified on-site:

- Agricultural land uses and land used as a golf course;
- Infilled land; and
- Historical Electrical Substation.

8.1.1.2 Off-site Sources

An off-site sewage farm has been present from 1899, located approximately 100 m from the site to the south. Residential developments were completed in the wider area during the 1960s to 1970s, plus isolated buildings which are assumed to be associated with farming practices.

Based on historical and existing land uses, the following potential sources of contamination have been identified within 500 m from the site:

- Sewage Farm (located approximately 100 m south of the site);
- Agricultural land uses; and
- Electrical Substation.
- Uncontrolled flytipping has been noted in the Freek's Farm site to the east. The Freek's Farm site has been investigated previously (AECOM, 2019) and it is understood that the waste has been remediated as part of previous phases of work. As such it is not considered to be a viable source of contamination to the site.

Potential sources of contamination located at more than 250 m from the site are considered unlikely to affect ground conditions at the site and are therefore not considered further in this assessment.

8.1.1.3 Contaminants of Potential Concern

Based on the potentially contaminative land uses described above, the following contaminants of potential concern (CoPC) have been identified:

- Asbestos;
- Metals;
- Organic and Inorganic compounds;
- Polycyclic aromatic hydrocarbons (PAH);

- Petroleum hydrocarbons (TPH);
- benzene, toluene, ethyl benzene, and xylenes (BTEX) and Methyl tert-butyl ether (MTBE);
- Poly-chlorinated biphenyls (PCBs);
- Volatile and semi-volatile organic compounds (VOCs and SVOCs);
- Pesticides and herbicides; and
- Sulphate.

8.1.2 Potential Pathways for Exposure and Migration

For the purpose of this assessment, the principal pathways for contaminant exposure and migration are considered to be as follows:

- Human Health:
 - Direct contact (soil ingestion, dermal contact, dust ingestion/inhalation) with contaminated soils and asbestos fibres in areas of soft standing;
 - Plant uptake and consumption of homegrown produce from private gardens; and
 - Migration of vapours and ground gases via permeable strata to enclosed spaces, with subsequent inhalation by building occupants (in future residential buildings) or on-site maintenance workers (in service inspection chambers, if present).
- Controlled Waters:
 - Leaching of contaminants and vertical migration through permeable unsaturated strata into groundwater; and
 - Lateral and vertical migration via the underlying groundwater.
- Risks to property:
 - Corrosion of concrete and ground structures and services; and
 - Gas ingress to buildings and creation of hazardous atmospheres

8.1.3 Potential Receptors

For the purposes of this assessment, the principal receptors are as follows:

- Human health:
 - site users, including future residents, maintenance workers, and visitors; and
 - Neighbouring residential receptors and site visitors.
- Controlled Waters:
 - Groundwater, the secondary A Aquifer of the Alluvium and the Horesham Stone Member. The site is not located within 500m of an SPZ. The Weald Clay is classified as an unproductive stratum so is not considered to be a viable receptor.
 - Surface Water: the nearest surface water feature are two tributaries of the River Adur which are present on-site and several ponds present at the site.
- Building structures and services.
 - Below ground elements of the proposed housing development, associated infrastructure and services.
 - Any above ground buildings and enclosed spaces where gases could potentially enter and accumulate.

It should be noted that the CSM considers the long-term use of the site rather than potential short-term and typically higher frequency of exposure for construction and maintenance workers carrying out earthworks or below-ground maintenance (e.g. repair of underground utilities).

These short-term potential exposure routes should be managed using appropriate health and safety controls during the construction and operational phases, respectively. As such, construction workers are not considered further as receptors in this assessment.

8.1.4 Preliminary Risk Assessment

In accordance with Land Contamination Risk Management (LCRM) guidance, the Tier 1 assessment has identified a range of viable contaminant linkages. The approach to the preliminary risk assessment has been based on the CIRIA C552 guidance (Contaminated Land Risk Assessment: A Guide to Good Practice). For each pollutant linkage an estimate of the potential severity (consequence) and probability (likelihood) has been undertaken. Table 8.4 below summarises the identified linkages and the identified risk magnitude.

Using criteria based on those presented in the Construction Industry Research and Information Association (CIRIA) publication C552, the magnitude of the risk associated with potential contamination at the site has been assessed. To do this an estimate is made of:

- The magnitude of the potential consequence (i.e., severity).
- The magnitude of probability (i.e., likelihood).

The severity of the risk is classified according to the criteria in Table 8-1 below.

Table 8-1 Classification of Severity

Risk	Description
Severe	• Short term (acute) risks to human health likely to result in "significant harm" as defined by Part 2A of the Environment Protection Act 1990 (e.g., high concentrations of cyanide at the surface in recreational areas) • Catastrophic damage to buildings/property (e.g., potential for explosion causing building to collapse) • Short term risk pollution / major pollution of controlled waters (e.g., major spillage of contaminants into controlled waters) • Short term risk to a particular ecosystem or organism forming part of an ecosystem
Medium	• Chronic (long-term) risk to human health likely to result in "significant harm" (contaminant concentrations exceeding generic or site-specific assessment criteria) • Pollution of sensitive controlled waters (e.g., leaching of contaminants into surface watercourses or principal / secondary aquifers) • Significant change in an ecosystems or organism forming part of an ecosystem (e.g., death of a species within a designated nature reserve)
Mild	• Pollution of non-sensitive waters (e.g., unproductive strata) • Significant damage to crops, buildings, structures and / or services (e.g., rendering a building unsafe to occupy from instability due to foundation damage) • Damage to sensitive buildings, structures, services or the environment
Minor	• Harm, although not necessarily significant harm, which may result in financial loss or expenditure to resolve (e.g., loss of plants in a landscaping scheme) • Non-permanent human health effects to humans (easily prevented by means such as personal protection clothing) • Easily repairable damage to buildings, structures or services

The probability of the risk occurring is classified according to the criteria shown in Table 8-2.

Table 8-2 Classification of Probability

Probability	Description
High Likelihood	• There is a pollution linkage and an event either appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution
Likely	• There is a pollution linkage and all the elements are present and in the right place which means that it is probable that an event will occur
Low Likelihood	• There is pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and it is less likely in the shorter term.
Unlikely	• There is a pollution linkage but circumstances are such that is improbable that an event would occur even in the very long term.

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 8-3.

Table 8-3 Risk Evaluation

		Severity			
		SEVERE	MEDIUM	MILD	MINOR
Likelihood	HIGH	Very High	High	Moderate	Moderate/Low
	LIKELY	High	Moderate	Moderate/Low	Low
	LOW	Moderate	Moderate/Low	Low	Very Low
	UNLIKELY	Moderate/Low	Low	Very Low	Very Low

Table 8-4 Summary of Tier 1 identified potential linkages.

Source	Pathway	Receptor	Severity	Likelihood	Risk Rating	Comments
On-site: Agricultural land uses, Infilled land and Historical Electrical Substation	Dermal absorption or ingestion of soil	Human Health: Future site users, including residential property users, community facility users, maintenance workers, and members of the public; and Off-site residents and workers.	Medium	Low	Moderate / Low	Limited potential within no significant contamination sources identified.
<i>(Potential contaminants including but not limited to asbestos, metals, PAH, TPH, PCBs, SVOCs, VOCs, Pesticide & Herbicide, Organic and Inorganic compounds, ground gases)</i>	Plant uptake and consumption of homegrown produce	Human Health: Future site users, including residential property users and community gardens.	Medium	Low	Moderate/Low	Limited potential within no significant contamination sources identified.
	Migration of contaminants via airborne dusts followed by inhalation.	Human Health: Future site users, including residential property users, community facility users, maintenance workers, and members of the public; and Off-site residents and workers.	Medium	Low	Moderate / Low	Limited potential within no significant contamination sources identified.
	Leaching of chemicals and vertical migration via permeable unsaturated strata into groundwater	Controlled Waters: Groundwater, specifically the secondary A Aquifer of Alluvium.	Medium	Low	Moderate / Low	Limited potential for elevated concentrations of chemical based on the identified sources. .
	Lateral migration of impacted groundwater off-site towards surface water	Controlled Waters: Surface water, tributaries for the River Adur, and surface water ponds.	Mild	Low	Low	Limited potential for elevated concentrations of chemical and a limited pathway to adjacent surface water receptors, unlikely to exceed EQS criteria.
	Direct contact causing corrosion of sub-surface concrete foundations and ground structures/services with aggressive ground conditions	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services, and landscaped area.	Mild	Low	Low	Limited potential for elevated concentrations of corrosive aggressive chemical environments and limited underground infrastructure.
	Migration of hazardous gases and organic vapours via permeable strata and/or through preferential pathways created by buried services – creation of hazardous atmospheres and vapour inhalation	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services, and landscaped area. Human Health: Future site users, including residential property users, community & occupational facility users, maintenance workers, and members of the public; and Off-site residents and workers.	Mild	Low	Low	Limited potential for elevated concentrations of ground gases

Source	Pathway	Receptor	Severity	Likelihood	Risk Rating	Comments
	Lateral migration of impacted groundwater towards the site	Controlled Waters: Groundwater, specifically the secondary A Aquifer of the Alluvium.	Mild	Low	Low	Minimal potential for elevated concentrations of chemical and a limited pathway to underlying aquifers.
Off site sources: Sewage Farm (located ~ 100 m south of the site), Agricultural land uses, Electrical Substation, Historical contamination of adjacent land (i.e. Freeks Farm fly tipping). (Potential contaminants including but not limited to asbestos, metals, PAH, TPH, PCBs, SVOCs, VOCs, Pesticide & Herbicides, Organic and Inorganic compounds)	Migration of contaminants via airborne dusts followed by inhalation.	Human Health: Future site users, including residential property users, community & occupational facility users, maintenance workers, and members of the public.	Medium	Unlikely	Low	Limited anticipated presence of airborne dust from adjacent site activities
	Migration of hazardous gases and organic vapours onto the site via permeable strata and/or through preferential pathways created by buried services	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services, and landscaped area. Human Health: Future site users, including maintenance workers	Mild	Low	Low	Limited potential for elevated concentrations of ground gases
	Lateral migration of impacted groundwater towards the site	Controlled Waters: Groundwater, specifically the secondary A Aquifer of the Alluvium.	Mild	Low	Low	Minimal potential for elevated concentrations of chemical from off site sources to aquifers underlying site
	Lateral migration of impacted Surface water towards the site	Controlled Waters: Surface water, tributaries for the River Adur	Mild	Low	Low	Minimal potential for elevated concentrations of chemical from off site sources to surface water present on site

8.2 Ground Investigation

As described in Section 4 a GI was completed at the site between 17th July to 22nd August 2023, followed by six rounds of ground gas and groundwater monitoring which began on 14th September 2023 and was completed on the 9th November 2023

Geo-environmental laboratory analysis was carried out on selected soil samples collected during the ground investigation. Groundwater sampling and ground gas monitoring was carried out post-fieldwork. A Factual Report detailing the work completed is provided in Appendix C.

8.2.1 Geo-environmental Soil Sampling

A total of 242 soil samples have been taken during the excavation of 20 Rotary Core Boreholes (BH01-20), 18 Dynamic Sampling Boreholes (DS01-18), 3 Road Cores (RC01-03) and 42 Trial Pits (TP01-39, 41, 45-46) with 123 samples scheduled for laboratory soil analysis and 49 samples scheduled for soil leachate/WAC analysis. The analyses undertaken were for a variety of chemicals (detailed in Section 4.3 above) and selected based on the current/historical land uses of the site. Soil samples were obtained from a range of depths extending from between 0.1m bgl to 6.6-6.7m bgl.

Asbestos was not observed within any of the exploratory locations and was not detected in any of the 122 samples scheduled for asbestos identification analysis.

Full details of the samples taken during the GI, borehole logs and laboratory certificates are provided in the factual report in Appendix C with the ground conditions encountered discussed in Section 5 above.

The site location plan and exploratory hole location plans are provided in Appendix A

8.2.2 Groundwater Monitoring and Sampling

Three groundwater monitoring events took place during the ground investigation occurring between 2nd and 13th August 2023, a further six groundwater monitoring events were undertaken post site works completion between 14th September 2023 and 9th November 2023, which involved taking water level readings from a total of 46 monitoring wells using an oil-water interface probe.

Groundwater sampling was undertaken during either on Monitoring Round 2 on 20/21 September 2023 or monitoring Round 5 on 11/12 October 2023, with samples collected from 20 well installations. The samples were collected from standpipes with response zones within the Weald Clay Formation.

No water samples were collected from the shallow 19mm standpipes.

The groundwater levels from the boreholes are provided in Section 5.3 above and in the 2023 factual report in Appendix C.

8.2.3 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of contamination was recorded at any of the exploratory locations.

Headspace readings of soil samples were taken on-site during borehole development monitoring for volatile vapours using a MiniRAE Lite Photoionization Detector (PID) with a 10.6eV gas discharge lamp. 16 PID readings reported a concentration greater than the method detection limit, ranging from 0.1 – 2.7ppm, with the highest reading noted in TP03 at 1.0m bgl. All samples with readings >0.5ppm were scheduled for VOC/SVOCs analysis.

8.2.4 Ground Gas

Six rounds of ground gas monitoring were undertaken between 14th September 2023 and 9th November 2023. Ground gas concentrations were recorded at 26 monitoring wells.

No ground gas monitoring was undertaken from the shallow 19mm standpipes.

The results are presented in the factual report in Appendix C.

8.3 Contamination Assessment

8.3.1 Generic Quantitative Risk Assessment (GQRA) Methodology

The GI undertaken at the site is detailed in the factual report in Appendix C. The report provides preliminary information on ground conditions and includes details on the soil and groundwater samples obtained and scheduled for chemical analysis. AECOM has completed a Tier 2 Generic Quantitative Risk Assessment (GQRA) in general accordance with Land Contamination Risk Management (LCRM) guidance for the chemical data collected as part of the GI works.

The purpose of GQRA as defined in LCRM guidance is to establish where Generic Assessment Criteria (GAC) and assumptions about a site are appropriate for assessing risks and, if so, to apply them to site data in order to establish whether there are actual or potentially unacceptable risks.

The GQRA also determines whether further detailed assessment is required. In doing so, it confirms whether the potential contaminant linkages identified in the preliminary risk assessment are of concern or not.

The assessment methods and criteria adopted for the GQRA are described below, followed by a comparison of the analytical data against the assessment criteria. The tabulated data screened against the relevant human health (HH) and controlled waters (CW) assessment criteria are included in Appendix K.

8.3.2 Human Health Screening Assessment Methodology

8.3.2.1 Selection of Human Health Generic Assessment Criteria Soils

Stage 1, Tier 2 GQRA has been undertaken in general accordance with LCRM guidance as an initial conservative screen based on default assumptions about land use, soil type and pathway.

The likely pathways associated with risk to human health, relevant to the GQRA are:

- Direct contact (ingestion, dermal contact, inhalation of dusts) with contaminated soils and groundwater during future use (by residents or maintenance workers).
- Plant uptake and consumption of homegrown produce from private gardens; and
- Exposure to contaminants via the vapour intrusion pathway for future site users or maintenance workers, including the potential for maintenance workers to be exposed to vapours if accessing inspection chambers.

Soils results have therefore been assessed using assessment criteria appropriate to pathways including direct contact, plant uptake and vapour intrusion.

AECOM understands that the future site redevelopment will comprise residential properties with gardens, commercial buildings and associated infrastructure. To assess the risk to future users of the site assessment criteria has been selected based on the scenario of 'residential with plant uptake' at 1% SOM for a sandy soil. They have also been screen based on the scenario of 'Public open space Park' at 1% SOM for sandy soil. Genotoxic PAHs have been screened using the surrogate marker approach (CL:AIRE, 2014).

AECOM has screened the soil data against human health GACs taken from various published sources from authoritative organisations including:

- C4SLs (CL:AIRE Phase 2 C4SLs (2021)).
- Defra Category 4 Screening Levels (C4SLs) (2014) and CL:AIRE C4SLs (2021).
- AECOM modified C4SLs (using CLEA v1.071).
- Land Quality Management/Chartered Institute of Environmental Health (LQM/CIEH) Suitable 4 Use Levels (S4ULs) 2015.
- Environmental Industries Commission (EIC) and Association of Geotechnical & Geo-environmental Specialists (AGS) and CL:AIRE GAC.
- AECOM GAC, modified EIC.
- Dutch Soil Remediation Circular 2013 - Soil Intervention Values [& soil type correction].
- US Environmental Protection Agency, Regional Screening Levels, Nov 2021.

In addition groundwater samples have been compared to HH groundwater vapour GAC:

- The Society of Brownfield Risk Assessment Groundwater GAC Residential. 2017

8.3.3 Human Health GQRA

The soil data was screened against residential GAC (with plant uptake) as well as public open space (parks) GAC. The results indicate that there were five samples with exceedances of the residential GAC, all for PAH or TPH. The samples were RC01 0.13-0.23 m bgl and 0.4-0.5 m bgl, RC02 0.4-0.5 m bgl, RC03 0.2-0.3 and 0.4-0.5 m bgl with details noted in Table 8-5 below. The samples denoted 'RC' were taken from beneath existing roadways of Cuckfield Road – B2036 and Isaac's Lane – A273. All samples taken with exceedances are of made ground deposits beneath asphalt and concrete road surfaces. The borehole log for RC01 identified coal and tarmacadam within the sampled horizon. Although these materials were not reported in the sampled horizons at RC02 and RC03 the general description of the sampled made ground was similar to that at RC01 and therefore the PAH and TPH exceedances are likely to be a result of the roadway construction (asphalt and underlying sub-base containing fragments of coal and tarmac).

Soil analytical data also recorded three exceedances for of the Public open spaces GAC were reported, RC01 0.13-0.23m bgl, RC02 0.4-0.5m bgl and RC03 0.2-0.3m bgl.

It should also be noted that the Method Detection Limit (MDL) available during analysis for a number of compounds¹ exceeded the residential GAC. However, none of the compounds were reported at concentrations above the MDL in any sample and therefore there is no evidence that they are present on site.

The laboratory chemical analysis results are presented in Appendix C within the Factual Report. Screening tables are reported in Appendix K of this report.

Table 8-5 Soil samples exceedances of GAC

Chemical Analysis	Unit	GAC HH POS PRK SAND 0.58- 1.45%TOC		GAC HH RES+PL SAND 0.58- 1.45%TOC		Maximum Value
		Number of Exceedances	GAC Value	Number of Exceedances	GAC Value	
>EC16-EC21 Aromatics	mg/kg	0	7500	1	260	850
>EC21-EC35 Aromatics	mg/kg	0	7800	1	1100	1700
Naphthalene	mg/kg	0	670	2	0.85	18
Phenanthrene	mg/kg	0	6200	2	95	470
Fluoranthene	mg/kg	0	6300	2	280	470
Benz(a)anthracene*	mg/kg	2	54	3	7.2	190
Chrysene*	mg/kg	2	110	2	15	180
Benzo(a) pyrene	mg/kg	2	21	3	5	180
Indeno(1,2,3-c,d) pyrene*	mg/kg	0	170	2	27	120
Dibenz(a,h) anthracene*	mg/kg	3	1.3	5	0.24	18
Benzo(b) fluoranthene*	mg/kg	2	15	3	2.6	130
Benzo(k) fluoranthene*	mg/kg	0	420	1	77	84

* Assessed using the Surrogate Marker approach (CL:AIRE, 2014)

GAC_HH_POS_PRK_SAND_0.58-1.45%TOC = 'Human Health _Public open space_Park' Sandy Soils at 0.58-1.45% Total Organic carbon

GAC_HH_RES+PL_SAND_0.58-1.45%TOC = 'Human Health _residential with Plant Uptake_ Sandy Soils at 0.58-1.45% Total Organic carbon

¹ b-BHC, g-BHC (Lindane), Dichlorvos, 1,2-Dinitrobenzene, 1,3-Dinitrobenzene, 1,4-dinitrobenzene, 1,2,4-trichlorobenzene, Pentachlorophenol, 2-chloronaphthalene, 2,4-Dinitrotoluene, 2,6-dinitrotoluene, Azobenzene, Hexachlorobenzene, Hexachlorocyclopentadiene, 4,6-Dinitro-2-methylphenol (all 0.1mg/kg), Vinyl chloride, 1,2-dichloroethane, Trichloroethene, 1,2-dichloropropane, 1,2,3-trichloropropane and 1,2-dibromo-3-chloropropane

8.3.3.1 Hazard Index for TPH Assessment

The Environment Agency Report "The UK Approach for Evaluating Human Health Risk from Petroleum Hydrocarbons in Soils" (SR:P5-080/TR3, 2005) states that even where guideline values for the individual TPH fractions are not exceeded potential additive toxicological effects between the fractions may result in a potential risk to human health.

The calculated HQ and HI are reported in Appendix K.. In total, 24 soil samples have been analysed for the TPH-CWG chemical suite. One soil sample (RC03 0.2-0.3 m bgl), records a HI with a value of 5.94, due to relatively high concentrations of >EC16-EC21 Aromatics & >EC21-EC35 Aromatics relative to the GAC values. The likely source of these hydrocarbons are the road surfacing asphalt and associated sub-base made ground horizons as no odours/staining was noted in the exploratory log.

8.3.3.2 Asbestos Analysis and Assessment

No asbestos was recorded in the 122 samples submitted for asbestos identification analysis.

8.3.3.3 Groundwater Vapour Assessment

Groundwater samples were screened against Groundwater Vapour GAC (SOBRA, 2017). There were no exceedances of Groundwater Vapour GAC.

8.3.4 Controlled Waters Screening Assessment Methodology

8.3.4.1 Selection of Controlled Water Generic Assessment Criteria

Risks to controlled waters have been assessed using a tiered approach based on that described in the EA's Remedial Targets Methodology (RTM).

Groundwater data and soil leachate data have been screened against controlled waters GAC that are designed to be protective of drinking water standard (GAC_WTV_EN/WA_DWS) and fresh surface water sources (GAC_WTV_EN/WA_EQS-Fresh).

Controlled waters GAC selected for groundwater are primarily Environmental Quality Standards (EQS) for protection of surface water and England & Wales Drinking Water Standards (DWS) for aquifer protection. However, these are not published for certain determinants and so, in the absence of an EQS or DWS, reference has been made to the following in order of preference:

GAC_WTV_EN/WA_DWS

- Water, England & Wales - Water Supply (Water Quality) Regulations, 2016 No. 614;
- Guidelines for Drinking-water Quality (4th Edition inc. the First Addendum). World Health Organisation. 2017;
- WHO, Petroleum Products in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality WHO/SDE/WSH/05.08/123, 2008;
- Drinking Water Guidelines Calculated using WHO Methodology; and
- US Environmental Protection Agency, Regional Screening Levels, Nov 21. Tapwater.

GAC_WTV_EN/WA_EQS-Fresh

- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - AA-EQS Inland;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - MAC-EQS Inland;
- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 - Freshwater Standards;
- The Water Environment (River Basin Management Planning etc.) (Miscellaneous Amendments) (Scotland) Regulations 2015. Scottish SI 2015 No. 211. AA-EQS Inland; and
- SEPA - Supporting Guidance (WAT-SG-53) Environmental Quality Standards for Discharges to Surface Waters. v6. Dec 2015. Fresh EQS – AA.

8.3.5 Controlled Waters GQRA

Details of the exceedances noted within the soil leachate samples can be observed are summarised within Table 8-7 below.

Table 8-6 Soil leachate samples exceedances of GAC

Chemical Analysis	Unit	<u>GAC WTV EN/WA DWS</u>		<u>GAC WTV EN/WA EQS-Fresh</u>		Maximum Value
		Number of Exceedances	GAC Value	Number of Exceedances	GAC Value	
>EC16-EC21 Aromatics	µg/L	1	90	-	-	260
>EC21-EC35 Aromatics	µg/L	1	90	-	-	570
Dichloromethane	µg/L	1	20	1	20	52
Naphthalene	µg/L	0	6	1	2	5.6
Acenaphthylene	µg/L	1	18	-	-	25
Acenaphthene	µg/L	1	18	-	-	19
Fluorene	µg/L	1	12	-	-	29
Anthracene	µg/L	0	90	3	0.1	59
Fluoranthene	µg/L	1	4	11	0.0063	7.4
Benz(a)anthracene	µg/L	2	3.5	-	-	210
Chrysene	µg/L	1	7	-	-	180
Benzo(a) pyrene	µg/L	4	0.01	4	0.00017	3.7
Indeno(1,2,3-c,d)pyrene	µg/L	3	0.1	-	-	2.4
Dibenz(a,h) anthracene	µg/L	2	0.07	-	-	32
Benzo(g,h,i)perylene	µg/L	3	0.1	4	0.0082	2.2
Benzo(b)fluoranthene	µg/L	3	0.1	4	0.017	3.6
Benzo(k)fluoranthene	µg/L	2	0.1	3	0.017	1.5
PAHs (sum of 4)	µg/L	3	0.1	-	-	9.7
Cadmium	µg/L	0	5	1	0.08	0.08
Copper	µg/L	0	2000	23	1	7.3
Lead	µg/L	0	10	2	1.2	1.5
Zinc	µg/L	0	6000	1	10.9	20
Chromium (Trivalent)	µg/L	0	50	1	4.7	5.3
Ammoniacal Nitrogen	mg/L	1-	0.5	3	0.3	0.7

GAC_WTV_EN/WA_DWS = 'Water Target Values_England and Wales_ Drinking Water Standard

GAC_WTV_EN/WA_EQS-Fresh = 'Water Target Values_England and Wales_ Environmental Quality Standard_Freshwater.

Details of the exceedances noted within the groundwater samples are summarised below.

Table 8-7 Groundwater samples exceedances of GAC

Chemical Analysis	Unit	<u>GAC WTV EN/WA DWS</u>		<u>GAC WTV EN/WA EQS-Fresh</u>		Maximum Value
		Number of Exceedances	GAC Value	Number of Exceedances	GAC Value	
>C21-C35 Aliphatics	µg/L	1	300	-	-	470
Fluoranthene	µg/L	0	4	3	0.0063	1.1

Chemical Analysis	Unit	GAC WTV EN/WA DWS		GAC WTV EN/WA EQS-Fresh		Maximum Value
		Number of Exceedances	GAC Value	Number of Exceedances	GAC Value	
Benzo(a) pyrene	µg/L	1	0.01	1	0.00017	0.12
Indeno(1,2,3-c,d)pyrene	µg/L	1	0.1	-	-	0.15
Benzo(g,h,i)perylene	µg/L	1	0.1	1	0.0082	0.16
Benzo(b)fluoranthene	µg/L	1	0.1	1	0.017	0.25
Benzo(k)fluoranthene	µg/L	1	0.1	1	0.017	0.12
PAHs (sum of 4)	µg/L	1	0.1	-	-	0.68
Cadmium (Filtered)	µg/L	0	5	2	0.08	0.35
Copper (Filtered)	µg/L	0	2000	15	1	11
Lead (Filtered)	µg/L	0	10	3	1.2	2.1
Nickel (Filtered)	µg/L	1	20	9	4	62
Selenium (Filtered)	µg/L	2	10	-	-	23
Zinc (Filtered)	µg/L	0	6000	18	10.9	180
Chromium (Trivalent) (Filtered)	µg/L	0	50	1	4.7	16
Ammoniacal Nitrogen	mg/L	3	0.5	4	0.3	1.5

It is noted that the laboratory method detection limits are in some instances greater than the corresponding GAC guidelines.

Exceedances of DWS have been recorded within groundwater samples collected from four locations. BH06 for >C21-C35 Aliphatics, BH14 & DS09 for selenium, and DS18 for PAH compounds (benzo(a) pyrene, indeno(1,2,3-c,d)pyrene, benzo(g,h,i)perylene, benzo(b)fluoranthene, benzo(k)fluoranthene, PAHs (sum of 4)) and nickel.

Exceedances of EQS have been noted within all 26 groundwater samples for at least one compound: 4No for ammoniacal nitrogen, 18No for zinc, 15No for copper, 9No for nickel, 3No for lead and fluoranthene, 2No for cadmium, and 1No exceedance for the following PAH compounds; benzo(a)pyrene, benzo(g,h,i)perylene, benzo(b)fluoranthene, benzo(k)fluoranthene and chromium (Trivalent).

In soil leachate samples, exceedances of DWS were only recorded for TPH >EC16-EC21 Aromatics and >EC21-EC35 Aromatics at a single location. PAH compounds were recorded above DWS for: 1no acenaphthylene, 1No acenaphthene, 1No fluorene, 1No fluoranthene, 2No benz(a)anthracene, 1No chrysene, 4No benzo(a) pyrene, 3No indeno(1,2,3-c,d)pyrene, 2No dibenz(a,h)anthracene, 3No benzo(g,h,i)perylene, 3no benzo(b)fluoranthene, 2No benzo(k)fluoranthene and 3No PAHs (sum of 4). Dichloromethane was also recorded at one location (TP15, 0.1-0.2m) above DWS.

Soil leachate analysis recorded exceedances for EQS for: 1no dichloromethane, 1no naphthalene, 3no anthracene, 11no fluoranthene, 4no benzo(a) pyrene, 4no benzo(g,h,i)perylene, 4no benzo(b)fluoranthene, 3no benzo(k)fluoranthene, 1no cadmium, 23no copper, 2no lead, 1no zinc, 1no chromium (Trivalent) and 4no Ammoniacal Nitrogen.

8.4 Ground Gas

Monitoring of ground gas concentrations was undertaken during six monitoring rounds between 14 September and 9 November 2023.

The range of gas concentrations, flow rates and atmospheric pressures recorded is presented in Table 8-8. Recorded atmospheric pressure ranged between 972 mbar and 1033 mbar throughout the monitoring period.

It is noted that the following limitations apply to the assessment:

- Not all monitoring well installations were monitoring during each monitoring round, and monitoring of shallow monitoring well installations was not undertaken;
- Generally high atmospheric pressure conditions (>1000 mB) were recorded throughout the majority (5 of 6) of the monitoring rounds; and
- 12 of the monitoring wells had the response zones fully saturated during all of their monitoring period, with a further seven monitoring wells having response zone fully saturated on at least one of the monitoring rounds,

The results of the ground gas monitoring are summarised in Table 8-8.

Table 8-8 Summary of Ground Gas Monitoring Results

Well	Response Zone (m bgl)	Depth to water (m bgl)	No. of MR	Range. CH ₄ (% v/v)	Max Steady CH ₄ (% v/v)	Range. CO ₂ (% v/v)	Max Steady CO ₂ (% v/v)	Range. O ₂ (% v/v)	Min Steady O ₂ (% v/v)	Range. CO (ppm)	Max Steady CO (% v/v)	Range. H ₂ S (ppm)	Max Steady H ₂ S (% v/v)	Range Flow Rate (l/hr)	Max Steady Flow Rate (l/hr)	Range PID (ppm)	Max Steady PID (ppm)
BH01-D (50mm)	4.2 - 10.0	2.39 – 3.43	5*#	0 - 0	0	0.5 - 0	0.5	21.3 - 19.2	19.3	10 - 0	1	0 - 0	0	91 - -0.3	12.7	21 - 0	20.2
BH02-D (50mm)	2.1 - 5.5	2.2 – 3.67	6	0 - 0	0	5.6 - 0	4.8	21 - 10.8	12.4	0 - 0	0	0 - 0	0	20.1 - -10.6	4.7	12 - 0	7.2
BH03-D (50mm)	3.2 - 5.2	2.9 – 3.75	6@	0 - 0	0	1.4 - 0	1.2	21.6 - 18.9	19.1	0 - 0	0	0 - 0	0	57.9 - -7.3	9.6	5.2 - 0	3.8
BH04-D (50mm)	2.8 - 8.5	3.04 – 5.79	6	0 - 0	0	2.9 - 0	1.2	20.8 - 2.5	18.2	10 - 0	4.4	0 - 0	0	0 - -1.9	0	68.1 - 0	51.9
BH05-D (50mm)	1.6 - 6.5	1.6 – 1.83	6@	0 - 0	0	0.9 - 0	0.5	21.1 - 18.5	18.7	0 - 0	0	0 - 0	0	49.3 - 0	8.4	106 - 0	38.2
BH06-D (50mm)	4.0 - 8.0	3.21 – 3.9	6#	0 - 0	0	3.4 - 0	2.6	20.8 - 15	15.3	10 - 0	10	0 - 0	0	1 - -1	0.3	58.9 - 0	42.8
BH07-D (50mm)	3.4 - 8.5	3.98 – 4.36	6	0 - 0	0	8 - 0	2	20.7 - 0.4	3.4	0 - 0	0	0 - 0	0	0 - 0	0	6.6 - 0	4.3
BH08-D (50mm)	4.0 - 8.0	1.96 – 2.99	6#	0 - 0	0	2.4 - 0	2	21.1 - 10.6	12.6	10 - 0	10	0 - 0	0	1 - -8.1	0.1	4.9 - 0	4.3
BH10-D (50mm)	1.5 - 5.2	0.0 – 0.7	6#	1.6 - -0.1	1.6	6 - 0	1	20.8 - 18.3	18.3	10 - 0	10	0 - 0	0	18.3 - 0	7.7	3.1 - 0	2.7
BH11-D (50mm)	5.6 - 10.0	0.09 – 0.55	5*#	0 - -1.6	0	1 - 0	0.5	20.8 - 17.5	18.3	0 - 0	0	0 - 0	0	22.2 - -0.9	2.1	4.1 - 0	2.2
BH12-D (50mm)	4.0 - 10.5	5.31 – 5.51	6	0 - 0	0	3.1 - 0	2.9	20.9 - 0	0.2	10 - 0	9.5	0 - 0	0	3.4 - 0	2.8	11.9 - 0	8.8
BH13-D (50mm)	3.8 - 10.5	0.27 – 1.04	6#	0 - 0	0	1.5 - 0	0.8	20.7 - 14.5	15.0	10 - 0	5.6	0 - 0	0	6.1 - -15	0.4	14.7 - 0	10.5
BH14-D (50mm)	5.0 - 10.0	1.55 – 2.21	6#	0 - 0	0	2.2 - 0	1.9	20.7 - 11.9	13.1	10 - 0	10	0 - 0	0	38.5 - 0	4.8	9.1 - 0	6
BH15-D	4.0 - 10.5	0.53 – 2.15	6#	0 - 0	0	2.9 - 0	1.7	20.8 - 0	17.0	10 - 0	10	0 - 0	0	38.2 - 0	6.1	18.8 - 0	6.5

Well	Response Zone (m bgl)	Depth to water (m bgl)	No. of MR	Range. CH ₄ (% v/v)	Max Steady CH ₄ (% v/v)	Range. CO ₂ (% v/v)	Max Steady CO ₂ (% v/v)	Range. O ₂ (% v/v)	Min Steady O ₂ (% v/v)	Range. CO (ppm)	Max Steady CO (% v/v)	Range. H ₂ S (ppm)	Max Steady H ₂ S (% v/v)	Range Flow Rate (l/hr)	Max Steady Flow Rate (l/hr)	Range PID (ppm)	Max Steady PID (ppm)
(50mm)																	
BH17-D (50mm)	4.0 - 8.5	1.68 – 2.58	6#	0 - 0	0	19.9 - 0	1.6	20.8 - 18.9	19.2	10 - 0	10	0 - 0	0	115.9 - - 0.6	22	20.8 - 0	8.1
BH18-D (50mm)	4.0 - 8.5	1.82 – 2.9	6#	0 - -0.2	0	6.8 - 0	2	20.8 - 16.3	16.6	13 - 0	10	0 - 0	0	5.7 - 0	2.1	80.8 - 0	34.1
BH19-D (50mm)	4.0 - 8.5	0.33 – 1.2	6#	0 - 0	0	0.9 - 0	0.6	20.9 - 18.4	19.1	10 - 0	10	0 - 0	0	39 - -3.4	4.4	3.7 - 0	2.4
BH20-D (50mm)	4.0 - 8.5	2.42 – 3.05	6#	0 - 0	0	2 - 0	1.8	20.7 - 15.5	16.2	10 - 0	10	0 - 0	0	90 - 0	16.5	3.4 - 0	3.1
DS02-D (50mm)	3.0 - 4.78	1.1 – Dry	6@	0 - 0	0	0.7 - 0	0.3	21.4 - 20	20.4	0 - 0	0	0 - 0	0	3.1 - 0	0.4	35.3 - 0	22.7
DS07-D (50mm)	2.4 - 3.73	0.24 – 3.31	6@	0 - 0	0	1.9 - 0	1.9	20.8 - 19	19.0	0 - 0	0	0 - 0	0	11.2 - 0	2.2	4.9 - 0	3.7
DS09 (50mm)	0.5 - 2.54	0.82 – 1.1	6	0 - 0	0	0.6 - 0	0.5	21.2 - 17.7	18.2	10 - 0	8.5	0 - 0	0	0 - 0	0	34.1 - 0	20.1
DS10 (50mm)	0.5 - 2.67	0.17 – Dry	6@	0 - 0	0	2.2 - 0	1.5	20.8 - 13.7	18.7	10 - 0	8.9	0 - 0	0	8 - 0	0.6	31.1 - 0	25.2
DS11 (50mm)	0.5 - 1.85	0.76 – Dry	6	0 - 0	0	2.4 - 0	1.9	20.8 - 1.7	12.6	0 - 0	0	0 - 0	0	12.7 - - 0.2	2.2	4.3 - 0	2.3
DS15 (50mm)	0.8 - 2.5	Dry	6	0 - 0	0	1.5 - 0	1.2	20.7 - 18.9	19.5	10 - 0	10	0 - 0	0	4.9 - -0.4	0.6	80 - 0	41.9
DS17 (50mm)	0.5 - 1.98	0.05 – Dry	6@	0 - 0	0	6 - 0	6	21.1 - 19.5	19.7	10 - 0	10	0 - 0	0	5 - -20.8	2	0.7 - 0	0.3
DS18 (50mm)	0.5 - 1.99	0.3 – Dry	6@	0 - 0	0	3.1 - 0	2.5	20.7 - 14.1	16.5	10 - 0	10	0 - 0	0	9.5 - 0	0.7	11.9 - 0	3.6

* No Gas readings for Monitoring Round 1 (14th September 2023).# - Well response zone saturated during all monitoring rounds, @ - well response zone saturated during at least one round.

Groundwater levels have been recorded between 0.02 m bgl to 5.79 m bgl across the site, and 12 of the monitoring wells had the response zones fully saturated during all monitoring rounds, with a further seven monitoring wells having response zone fully saturated on at least one of the monitoring rounds. This data is summarised in Table 8-8 above.

Methane concentrations were predominantly reported below the instrument detection limit throughout monitoring. Concentrations above detection were only identified at two of the monitoring locations (BH10 & 11) within only BH10 returning a stable concentration above the instrument detection limit with a steady and peak concentration of 1.6% v/v, this was only observed during the first monitoring round (14/09/2023) and was during the well screen being saturated.

Carbon dioxide peak concentrations above instrument detection limits were reported at all monitored locations, with the highest steady concentration observed within monitoring well BH07, at 8% v/v, and was only observed during the 2nd monitoring round (20/09/2023).

Oxygen values range from 21.6 – 0.0% v/v across all monitored locations, with the highest recorded being at BH03 and the lowest at BH12 and BH15.

Carbon monoxide was detected above the detection limit within 18 locations (BH01, BH04, BH06, BH08, BH10, BH12-15, BH17-20, DS09-10, DS15, DS17), with 17 locations reporting a peak concentration of 10ppm, with BH18 reporting slightly higher at 13ppm, maximum steady concentration of 10ppm has been reported in all 12 locations it was observed within (BH06-D, BH08-D, BH10-D, BH14-D, BH15-D, BH17-D, BH18-D, BH19-D, BH20-D, DS15, DS17, DS18).

Hydrogen sulphide was not reported above the detection limit within any of the 24 monitored locations during the six monitoring rounds.

The highest flow rates were recorded at BH17 during the first monitoring round with a reading of 115.9 L/hr. It is noted that peak flow rates are generally significantly higher than the maximum steady flow rates. BH17 was flooded, and the high peak flow rate at this location is likely due to rising water levels within the well, which would have increased air pressure. The highest steady flow rate was 22 l/hr recorded at BH17 and was only reported during first monitoring round (14/09/2023) during which the well screen was saturated.

PID (VOC) monitoring levels has its peak recorded of 106ppm within BH05 during the 5th monitoring round. This high concentration was not replicated in other monitoring rounds and may be due to an instrument error such as interference from water vapour.

The borehole gas concentration and flow rate results for carbon dioxide (CO₂) and methane (CH₄) were compared to guidance values given in the following documents:

- BS 8485:2015+A1:2019 "Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings"; and
- CIRIA Report C665 (2007) "Assessing Risks Posed by Hazardous Ground Gases to Buildings"

In accordance with guidelines within BS8485, Gas Screening Values (GSVs) can be calculated to assess the significance of gas generation at the site. This is achieved by multiplying the percentage gas concentration (as a decimal) by the flow rates. A Gas Screening Value has been calculated for each monitoring well location based on the maximum gas concentration and maximum flow rate recorded in each monitoring well.

Gas screening values (GSV) can be calculated from the gas concentration and the flow rate:

$$GSV (l/hr) = \frac{\text{Gas concentration (\% v/v)}}{100} \times \text{flow rate (l/hr)}$$

The corresponding Characteristic Situation (CS) for the site is based on comparison of the generated GSVs to the values given in

Characteristic Situation	Risk Classification	Gas Screening Value (CH ₄ /CO ₂) l/hr	Additional Factors	Typical Source of Generation
1	Very Low	<0.07	Typically, CH ₄ <1% and CO ₂ <5%. Otherwise consider increase to CS2.	Natural Soil with low organic content. "Typical" Made Ground.

Characteristic Situation	Risk Classification	Gas Screening Value (CH ₄ /CO ₂) l/hr	Additional Factors	Typical Source of Generation
2	Low	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to CS3.	Natural Soil with high peat/organic content. "Typical" Made Ground.
3	Moderate	<3.5	-	Old landfill Inert waste Mineworking (flooded)
4	Moderate to High	<15	Quantitative Risk Assessment required to evaluate scope of protective measures.	Mineworking susceptible to flooding Completed Landfill (WMP 26b criteria)
5	High	<70	-	Mineworking unflooded inactive with shallow workings near the surface.
6	Very High	>70	-	Recent Landfill site

The initial approach in the assessment is to determine the (GSV) based on the maximum steady methane / carbon dioxide concentration and maximum steady state flow rate recorded at each location over the monitoring period. Calculated GSV are summarised in Table 8-10.

Table 8-10 Summary of Recorded Maximum Steady Gas Concentrations, Flows and CSV values

Well	Response Zone (m bgl)	Max. Steady Flow (l/hr)	Max. Steady Methane % (v/v)	Methane GSV (l/hr)	CS Value for CH ₄	Max. Steady CO ₂ % (v/v)	CO ₂ GSV (l/hr)	CS Value for CO ₂
BH02-D (50mm)	2.1 – 5.5	4.7	0	0	1	4.8	0.2256	2
BH04-D (50mm)	2.8 – 8.5	0	0	0	1	1.2	0	1
BH05-D (50mm)	1.6 – 6.5	8.4	0	0	1	0.5	0.042	1
BH07-D (50mm)	3.4 – 8.5	0	0	0	1	2	0	1
BH11-D (50mm)	5.6 – 10.0	2.1	0	0	1	0.5	0.0105	1
BH12-D (50mm)	4.0 – 10.5	2.8	0	0	1	2.9	0.0812	2
BH20-D (50mm)	0.5 – 2.67	16.5	0	0	1	1.8	0.297	2
DS07-D (50mm)	0.5 – 1.85	2.2	0	0	1	1.9	0.0418	1
DS09 (50mm)	0.5 – 1.98	0	0	0	1	0.5	0	1
DS10 (50mm)	0.5 – 1.99	0.6	0	0	1	1.5	0.009	1
DS11 (50mm)	4.2 – 10.0	2.2	0	0	1	1.9	0.0418	1
DS15 (50mm)	2.1 – 5.5	0.6	0	0	1	1.2	0.0072	1
DS17 (50mm)	2.8 – 8.5	2	0	0	1	6	0.12	2
DS18 (50mm)	1.6 – 6.5	0.7	0	0	1	2.5	0.0175	1

Table does not show data for well during which the well screen has been reported as saturated.

Flooded or partially flooded monitoring wells are considered to be an unreliable source of ground gas monitoring data and as such the wells which were fully flooded have been excluded from this assessment (BH01, BH06, BH10, BH13-BH19) Data from partially flooded wells is included but treated with caution (BH03, BH05, DS02, DS07, DS10, DS17 and DS18).

Based on the available dataset, the site should be given a classification of Characteristic Situation 1 (CS1) for methane. For carbon dioxide, the maximum Characteristic Situation was CS2 at BH02, BH12, BH20 and DS17, for each of these locations the maximum steady Carbon dioxide values and the maximum flow values have been taken from difference monitoring rounds, individual monitoring rounds returns as CS value of CS1. Overall, the site is considered to fall within Characteristic Situation 1 for both methane and carbon dioxide.

As noted at the beginning of this section, there are several limitations to the ground gas monitoring data. Many of the wells were flooded, the monitoring was generally undertaken during periods of relatively high pressure and shallow monitoring installations were not monitored. Nonetheless, the lack of identified ground gas sources on the site is considered to support the classification of CS1.

It is also noted that AECOM have undertaken a gas assessment on the Freeks Farm and Maple Drive site (AECOM, 2019), which is located within 250m of the site boundary. During the 2019 investigation 'No Methane concentrations and a maximum of 4.7% carbon dioxide (BH102) have been measured across the Freeks Farm site over four monitoring visits and a total of 15 ground gas installations. No flow was measured in any of the monitoring locations' The assessment at the site is therefore consistent with assessments for similar sites in the immediate area.

Table 8-9 Classification Scheme for site Gas Risk Assessment (modified Wilson and Card Classification)

Characteristic Situation	Risk Classification	Gas Screening Value (CH ₄ /CO ₂) l/hr	Additional Factors	Typical Source of Generation
1	Very Low	<0.07	Typically, CH ₄ <1% and CO ₂ <5%. Otherwise consider increase to CS2.	Natural Soil with low organic content. "Typical" Made Ground.
2	Low	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to CS3.	Natural Soil with high peat/organic content. "Typical" Made Ground.
3	Moderate	<3.5	-	Old landfill Inert waste Mineworking (flooded)
4	Moderate to High	<15	Quantitative Risk Assessment required to evaluate scope of protective measures.	Mineworking susceptible to flooding Completed Landfill (WMP 26b criteria)
5	High	<70	-	Mineworking unflooded inactive with shallow workings near the surface.
6	Very High	>70	-	Recent Landfill site

The initial approach in the assessment is to determine the (GSV) based on the maximum steady methane / carbon dioxide concentration and maximum steady state flow rate recorded at each location over the monitoring period. Calculated GSV are summarised in Table 8-10.

Table 8-10 Summary of Recorded Maximum Steady Gas Concentrations, Flows and CSV values

Well	Response Zone (m bgl)	Max. Steady Flow (l/hr)	Max. Steady Methane % (v/v)	Methane GSV (l/hr)	CS Value for CH ₄	Max. Steady CO ₂ % (v/v)	CO ₂ GSV (l/hr)	CS Value for CO ₂
BH02-D (50mm)	2.1 – 5.5	4.7	0	0	1	4.8	0.2256	2
BH04-D (50mm)	2.8 – 8.5	0	0	0	1	1.2	0	1
BH05-D (50mm)	1.6 – 6.5	8.4	0	0	1	0.5	0.042	1

Well	Response Zone (m bgl)	Max. Steady Flow (l/hr)	Max. Steady Methane % (v/v)	Methane GSV (l/hr)	CS Value for CH ₄	Max. Steady CO ₂ % (v/v)	CO ₂ GSV (l/hr)	CS Value for CO ₂
BH07-D (50mm)	3.4 – 8.5	0	0	0	1	2	0	1
BH11-D (50mm)	5.6 – 10.0	2.1	0	0	1	0.5	0.0105	1
BH12-D (50mm)	4.0 – 10.5	2.8	0	0	1	2.9	0.0812	2
BH20-D (50mm)	0.5 – 2.67	16.5	0	0	1	1.8	0.297	2
DS07-D (50mm)	0.5 – 1.85	2.2	0	0	1	1.9	0.0418	1
DS09 (50mm)	0.5 – 1.98	0	0	0	1	0.5	0	1
DS10 (50mm)	0.5 – 1.99	0.6	0	0	1	1.5	0.009	1
DS11 (50mm)	4.2 – 10.0	2.2	0	0	1	1.9	0.0418	1
DS15 (50mm)	2.1 – 5.5	0.6	0	0	1	1.2	0.0072	1
DS17 (50mm)	2.8 – 8.5	2	0	0	1	6	0.12	2
DS18 (50mm)	1.6 – 6.5	0.7	0	0	1	2.5	0.0175	1

Table does not show data for well during which the well screen has been reported as saturated.

Flooded or partially flooded monitoring wells are considered to be an unreliable source of ground gas monitoring data and as such the wells which were fully flooded have been excluded from this assessment (BH01, BH06, BH10, BH13-BH19). Data from partially flooded wells is included but treated with caution (BH03, BH05, DS02, DS07, DS10, DS17 and DS18).

Based on the available dataset, the site should be given a classification of Characteristic Situation 1 (CS1) for methane. For carbon dioxide, the maximum Characteristic Situation was CS2 at BH02, BH12, BH20 and DS17, for each of these locations the maximum steady Carbon dioxide values and the maximum flow values have been taken from difference monitoring rounds, individual monitoring rounds returns as CS value of CS1. Overall, the site is considered to fall within Characteristic Situation 1 for both methane and carbon dioxide.

As noted at the beginning of this section, there are several limitations to the ground gas monitoring data. Many of the wells were flooded, the monitoring was generally undertaken during periods of relatively high pressure and shallow monitoring installations were not monitored. Nonetheless, the lack of identified ground gas sources on the site is considered to support the classification of CS1.

It is also noted that AECOM have undertaken a gas assessment on the Freeks Farm and Maple Drive site (AECOM, 2019), which is located within 250m of the site boundary. During the 2019 investigation 'No Methane concentrations and a maximum of 4.7% carbon dioxide (BH102) have been measured across the Freeks Farm site over four monitoring visits and a total of 15 ground gas installations. No flow was measured in any of the monitoring locations'. The assessment at the site is therefore consistent with assessments for similar sites in the immediate area.

8.5 Contamination Assessment – Discussion

8.5.1 Future site Users

No observations of contamination were recorded during the ground investigation. No asbestos was recorded in any of the samples taken from the site.

The exceedances of the residential GAC are limited to five samples from three locations, RC01 0.13-0.23m bgl and 0.4-0.5m bgl, RC02 0.4-0.5m bgl, RC03 0.2-0.3m bgl and 0.4-0.5m bgl. Based on the current development plans, these locations are not due to be used for residential purposes as part of the proposed development, and will fall within the area of the local road infrastructure network.

For ground gas the site has been classified as Characteristic Situation 1: very low risk.

Overall, significant sources of contamination have not been identified at the site and risks to future site users are considered to be low.

8.5.2 Controlled Waters

The ground investigation has recorded the geology underlying the site as topsoil over Weald Clay (including weathered layers and 'residual soil'). The Weald Clay is classified as unproductive strata and is therefore not considered to be a viable Controlled Waters receptor. Alluvium was only recorded at three locations at the site, and is therefore not considered to be widespread at the site. The Horsham Stone Member was not identified in any exploratory holes at the site and is therefore unlikely to form a discrete groundwater unit at the site, if present at all. Therefore, in most areas of the site groundwater is not considered to be a controlled waters receptor. It could, however, form a potential pathway to surface water receptors.

The soil leachate and groundwater samples from the site both record exceedances of GAC for PAH, metals and ammoniacal nitrogen.

Metal concentrations in the soil samples collected from the site were generally within the range of background concentrations for the soil in the area. Background screening concentrations for the metals listed can be viewed in Section 3.3, and mean concentrations across the site were below the background concentrations. As such, and given no specific on-site sources have been identified, it is considered likely that the concentrations of metals detected in groundwater are indicative of the typical concentrations of metals for the area. In addition, the EQS for copper, nickel and zinc relate to bioavailability and, therefore, direct comparison of the chemical testing results is likely to be conservative. Overall, the recorded exceedances of DWS and EQS for metals are not considered to pose unacceptable risks.

PAH exceedances were largely limited to one location in groundwater (DS18) and four samples of soil leachate (RC01, RC02, RC03 and TP29). The exception is fluoranthene, which was widespread in soil leachate samples, albeit at concentrations close to the laboratory method detection limit. The PAH exceedances in RC01-RC03 can likely be attributed to the asphalt surfacing at these locations and fragments of tarmac and coal with the sub-base made ground (as reported in the borehole log for RC01). At TP29 there were no observations of asphalt in the sample or other contamination and the source of the PAH at this location is unknown. However, it is not considered to represent a widespread source of PAH across the site and is not considered to pose an unacceptable risk to controlled water receptors.

Sporadic exceedances of ammoniacal nitrogen were recorded in soil leachate and groundwater samples. In soil leachate the exceedances were typically at or close to the EQS/DWS. In groundwater, a notable concentration of 1.5 mg/L was recorded at BH06. The borehole log for this location and those in the vicinity do not record any observations of contamination, and there are no notable historical or present day sources in the area. As such the concentration recorded is not considered to be typical for the site. It is therefore unlikely to pose an unacceptable risk to controlled waters.

Based on the current condition of groundwater at the site, groundwater does not appear to be significantly impacted upon by soil contamination and unacceptable risks to groundwater and surface water receptors are not considered to be present.

8.6 Updated Conceptual Site Model

Following the GI and assessment of the available data, the preliminary CSM (previously presented in Table 8-4) has been updated to produce Table 8-11 below.

Table 8-11 Updated CSM

Source	Pathway	Receptor	Severity	Likelihood	Risk Rating	Comments
On-site: Agricultural land uses, Infilled land and Historical Electrical Substation	Dermal absorption or ingestion of soil	Human Health: Future site users, including residential property users, community & occupational facility users, maintenance workers, and members of the public; and Off-site residents and workers.	Medium	Unlikely	Low	Exceedance of soils of GAC are limited to samples due to be under road infrastructure and therefore limited possibility of exposure.
<i>(Potential contaminants including but not limited to asbestos, metals, PAH, TPH, PCB's, S/VOC's, Pesticide & Herbicide, Organic and Inorganic compounds, ground gas)</i>						
	Plant uptake and consumption of homegrown produce	Human Health: Future site users, including residential property users and community gardens.	Medium	Unlikely	Low	Exceedances of the Human Health residential with plant uptake GAC are isolated to an area of site due to remaining being road network, and therefore no exceedances for plant uptake are associated with area of respective final use.
	Migration of contaminants via airborne dusts followed by inhalation.	Human Health: Future site users, including residential property users, community & occupational facility users, maintenance workers, and members of the public; and Off-site residents and workers.	Medium	Unlikely	Low	No asbestos, or other hazardous airborne compounds, identified in samples submitted for analysis
	Leaching of chemicals and vertical migration via permeable unsaturated strata into groundwater	Controlled Waters: Groundwater, specifically the secondary A Aquifer of Alluvium.	Mild	Low	Low	Exceedances for DWS recorded for TPH, dichloromethane, PAH compounds and ammoniacal nitrogen. Concentrations largely within one order of magnitude of the DWS. No widespread contamination has been identified with exceedances isolated to individual locations with concentrations marginally above the respective GACs suggesting limited risk. Alluvium has only been identified at three locations at the site.

Source	Pathway	Receptor	Severity	Likelihood	Risk Rating	Comments
	Lateral migration of impacted groundwater off-site towards surface water	Controlled Waters: Surface water, tributaries for the River Adur, and surface water ponds.	Moderate	Unlikely	Low	Exceedances for EQS for leachate samples limited to dichloromethane, PAH compounds, metals and ammoniacal nitrogen. Metals are predominantly within the expected soil chemistry for the region and the other compounds are isolated exceedances with widespread contamination has been identified
	Direct contact causing corrosion of sub-surface concrete foundations and ground structures/services with aggressive ground conditions	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services, and landscaped area.	Mild	Low	Low	Assessment of concrete specification for aggressive soils has been undertaken, see Section 7.5.
	Migration of hazardous gases and organic vapours via permeable strata and/or through preferential pathways created by buried services – creation of hazardous atmospheres and vapour inhalation	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services. Human Health: Future site users, including residential property users, community facility users, maintenance workers, and members of the public; and off-site residents and workers.	Mild	Low	Low	The site has been classified as Characteristic Situation 1 – Very Low Risk, for carbon dioxide and methane.
	Lateral migration of impacted groundwater towards the site	Controlled Waters: Groundwater, specifically the secondary A Aquifer of the Alluvium.	Mild	Low	Low	Groundwater flow is suggested towards the surface water tributaries on site, and no sources so significant contamination are identified up gradient of the site.
Off site sources: Sewage Farm (located ~ 100 m south of the site), Agricultural land uses, Electrical Substation, Historical contamination of adjacent land (i.e. Freeks Farm fly tipping). (Potential contaminants including but not limited to asbestos, metals, PAH, TPH, PCB's,	Migration of contaminants via airborne dusts followed by inhalation.	Human Health: Future site users, including residential property users, community & occupational facility users, maintenance workers, and members of the public.	Medium	Unlikely	Low	Th sewage works and other sources are largely covered by buildings, hardstanding or vegetation (grass cover), which minimises the potential for dust generation from these sources.
	Migration of hazardous gases and organic vapours onto the site via permeable strata and/or through preferential pathways created by buried services	Property & infrastructure: Residential, commercial and community facilities, Infrastructure, services. Human Health: Future site users, including maintenance workers	Mild	Low	Low	The site has been classified as CS1 for ground gas and there is no evidence from available monitoring data that migration of ground gas from an offsite source is occurring.

Source	Pathway	Receptor	Severity	Likelihood	Risk Rating	Comments
S/VOC's, Pesticide & Herbicide, Organic and Inorganic compounds)	Lateral migration of impacted groundwater towards the site	Controlled Waters: Groundwater, specifically the secondary A Aquifer of the Alluvium.	Mild	Low	Low	Groundwater flow is suggested towards the surface water tributaries onsite, and no sources so significant contamination are identified up gradient of the site.
	Lateral migration of impacted Surface water towards the site	Controlled Waters: Surface water, tributaries for the River Adur	Mild	Low	Low	No sources so significant contamination sources have been identified upstream of the site.

9. Geotechnical & Geoenvironmental Risk Register

It is noted that Geotechnical Category Classifications are determined on the basis of the geotechnical works and risk implications.

The following geotechnical and geoenvironmental risks are anticipated:

- Unforeseen ground conditions might lead to construction delays and redesign (site specific risks are detailed below);
- Variability of Made Ground and presence of voids or obstructions;
- Localised weak/ compressible soils might lead to differential settlement and increased maintenance liability and cause differential settlement within foundations;
- The historical mapping indicates ponds/pits are present and then later are absent on the mapping. This could indicate locally infilled areas. Two trial pits identified Made Ground at these locations.
- Presence of Alluvium adjacent to streams and rivers
- Shrinkage or swelling of soils with volume change potential especially where trees are planted or removed;
- Variability of natural strata – presence of Horsham Stone Member and clay ironstone bands in Weald Clay Formation causing obstructions to foundations and excavations and potential for higher permeability leading to groundwater ingress;
- Legacy periglacial landscape resulting in reactivation of pre-existing shear surfaces at low slope angles parallel and sub-parallel to the ground surface (see Weeks, 1969);
- Unforeseen groundwater levels; high groundwater levels may lead to poor drainage and construction problems; artesian water leading to construction problems especially if cast in-situ bored piling is to be used, and flooding;
- Areas of unexpected contamination not documented on available mapping or other resources, or encountered during the ground investigation;
- Infilled pits or ponds;
- Presence of soils with low subgrade modulus requiring ground improvement for road design
- Presence of silt with potential for frost susceptibility requiring appropriate road design to ensure no damage to pavements
- Encountering unexploded ordnance might cause delays or endanger life;
- Encountering existing services. Cost and programme delays for reinstatement/ diversion of existing services, loss of life if gas/ electrical mains are hit; and
- Chemical attack on buried concrete which may result in maintenance problems.

More details regarding geotechnical risks can be found in the Geotechnical Risk Register below. The Geotechnical Risk Register is a live document and will be further developed and updated in the following reports with more recent information.

There is potential on site for ecological and arboriculture constraints which are not covered in this report.

The degree of risk (R) is determined by combining an assessment of the likelihood (L) of the hazard with an assessment of the severity (S) of the hazard. The scale against which the likelihood and severity are measured, and the resulting degree of risk determined is presented below.

Table 9-1 Classification of Probability and Impact

Likelihood (L)		Severity (S)	
Very Likely	5	Very High	5
Likely	4	High	4
Probable	3	Medium	3
Unlikely	2	Low	2
Negligible	1	Very Low	1

Table 9-2 Risk Matrix

Likelihood	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Severity				

Table 9-3 Classification of Risk Rating

Risk rating	Response
Intolerable	Unacceptable
Substantial	Early Attention
Tolerable	Regular Attention
Trivial	Monitor

Table 9-4 Geotechnical Risk Register

Identified Geotechnical Hazard	Cause	Risk before Control			Consequence	Mitigation Measures	Risk after Control		
		L	S	RR (LxS)			L	S	RR (LxS)
Existing Underground and Overhead Services at proposed site of works	Ground Investigation Works; site construction works, site clearance and site set-up (compound, haul roads etc.) At the time of writing this report out-dated utility drawings were available	4	4	16	The proposed GI works may encounter unforeseen services. Increased cost and delay to divert or lower services; Health & Safety impact during any excavations during Ground Investigation or construction; Relocation of ground investigation or site area to avoid overhead services; Scheme design alterations to avoid overhead/underground services.	Obtain up to date service plans and records; Undertake safe digging procedures in accordance with HSE publication HSG47 and PAS128; Undertake GPR surveys and mark out services prior to any investigations; Plan Ground Investigation to avoid buried and Overhead services; when working near overhead cables follow the guidance in HSE publication HSGS6 Design proposed scheme to minimise impact on existing services.	2	4	8
Unforeseen Ground Conditions	Variability in ground conditions across site	4	3	12	Unforeseen ground conditions e.g. Soft ground, variable thickness of Made Ground can cause programme delays	Project specific intrusive ground investigation must be carried out to improve the accuracy of ground models. Due to the inherent and variable nature of Made Ground conditions, variation is to be expected during the construction works and appropriate site monitoring by a competent engineer should be undertaken.	2	3	6
Natural obstructions/hard strata	Encountering obstructions in the form of hard limestone, sandstone and mudstone bands.	4	3	12	Obstructions can result in additional costs and programme delay	Findings from the site-specific GI should be reviewed and probing at pile locations should be considered	2	3	6
Secondary A aquifer contamination during GI or intrusive works	Water from excavations. Creation of new contamination pathways.	2	2	4	Water from excavations may contaminate the Secondary A Aquifer	Soil and groundwater arisings (e.g. water pumped from excavations) to be appropriately contained before any necessary treatment and disposal	1	2	2
Artesian Groundwater	Artesian groundwater pressures due to confined groundwater within Weald Clay Formation	3	3	9	Construction difficulties especially where bored cast in-situ piling used	Design should account for this potential when selecting foundation types and depths.	1	3	3
Buried obstructions	Intrusive GI and construction works	4	4	16	Intrusive GI and construction works could strike buried obstructions such as dis-used foundations and substructures	Prior to intrusive works the contractor should ensure that accurate and up-to-date As build existing drawings showing the locations of existing substructures, have been obtained and reviewed against the proposed works scope. Appropriate survey work should be carried out prior to commencing the intrusive works.	1	4	4
Aggressive Ground Chemistry	Concentrations of sulphate within Made Ground, Residual Soils or Weald Clay (weathered or unweathered)	4	2	8	Deleterious effects on buried concrete/piles. Pavement Heave. May impact some forms of ground improvement e.g. lime stabilisation.	Analyse BRE SD1 test results and design concrete mix and the additional protective measures during detailed design in accordance with BRE SD1 guidance. Consider presence during design of ground improvement.	1	3	3

Identified Geotechnical Hazard	Cause	Risk before Control			Consequence	Mitigation Measures	Risk after Control		
		L	S	RR (LxS)			L	S	RRR (LxS)
Localised weak/compressible soils, e.g. silt	May not support proposed load, may change seasonally or with planting	4	3	12	Instability, total and differential settlement and increased maintenance.	Appropriate ground investigation, design, excavation and replacement where required. Further ground investigation may need to be carried out to delineate areas of soft ground associated with watercourses.	3	2	6
High groundwater levels.	Surface water features and adjacent river tributaries on site	3	3	9	Poor drainage and construction difficulties.	Assess groundwater conditions prior to construction and design appropriate groundwater control and temporary support to excavations.	2	2	4
Poor drainage.	Low permeability soils present at surface	3	3	9	Construction difficulties leading to redesign, cost increase and project delay.	Assess drainage conditions prior to construction and design appropriate drainage measures.	2	2	4
Excavations causing slope instability.	Weak residual soils of weathered bedrock and Alluvium are present at site. Potential presence of preexisting slip surfaces that may be reactivated by excavations and other earthworks.	3	2	6	Slope failure. Possible impact on site safety. Increased cost and delay.	Fully supported trenches, limited open length to that which can be completed in one shift. Unsupported excavations may not be entered. During ground investigation observations should be recorded from the narrow end of the pit. Pits shall be backfilled immediately upon signs of instability. Close or continuous support will be required for any manned entry to excavations. Residual shear strengths may need to be considered in slope stability designs.	1	2	2
UXO	Historical UXO risk	2	5	10	Delays caused by clearance works or initiation endangering life.	Adopt appropriate mitigation measures.	1	5	5
Contaminated soils and groundwater	Localised contamination associated with past or present land uses that has not been identified during the GI completed.	3	3	9	Increased development costs, risks to human health and controlled waters	The ground investigation and risk assessment have not identified unacceptable risks to human health and controlled waters. Therefore, remediation is not considered to be required, and given the low risk historical land uses substantial previously unidentified impact is unlikely to be present. However, the potential for unexpected contamination to be uncovered during development works should be addressed through a Discovery Strategy within a Remediation Strategy for the site.	1	1	3
High compressible soils	Shrink swell of soils especially in vicinity of trees	4	3	12	Damage to structures particularly with moisture content changes	High volume change soils have been identified on the site. Adequate design considerations should be taken in areas of existing or proposed trees and other vegetation.	1	1	3

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