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A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

ENVIRONMENTAL STATEMENT
VOLUME 3B: TECHNICAL APPENDICES

July 2020

Volume 3B

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Welsh Government

A40 Llanddewi Velfrey to Penblewin Redstone Cross Improvements

Supplementary Preliminary Sources Study Report

A40LVP-ARP-HGT-J01-RP-C-0001

P02 | S4

01/09/17

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Executive Summary

A preliminary sources study of available information has been undertaken for the Redstone Cross Improvement section of the A40 Llanddewi Velfrey to Penblewin Improvement scheme. It is proposed to realign the existing section of A40 south of the existing alignment and tie into the existing Penblewin roundabout and Redstone Cross junctions.

This study comprises review of the topographical, geological, preliminary hydrological and hydrogeological conditions along the proposed route and historic and present-day development of the area.

An offline walkover was undertaken in March 2017. An online walkover along the proposed alignment will be completed in due course and will be discussed in the subsequent Ground Investigation Report.

No topographical surveys have been undertaken along the proposed alignment however there is limited historic LiDAR Data available. The proposed route leaves the current alignment of the A40 to continue in a south westerly direction to cross a valley associated with a watercourse. This limited LiDAR data shows the land drops steeply down to the watercourse crossing and then rises more gradually to meet the current A40 junction at Redstone Road at the western extremity of the site.

A known watercourse to the south follows an existing tree line which extends to cross the proposed route where the land gradually rises. This may be the continuation of the watercourse or the potential catchment areas of this watercourse. The LiDAR shows no real suggestion of a valley feature associated with watercourse but this historic and limited data may be inaccruate and the potential for an area which may be slightly lower feeding the southern watercourse might be present and should be investigated during the online walkover.

The surrounding area is predominantly agricultural and is shown on the historic maps to have altered very little over the past 150 years.

The underlying solid geology comprises Portfield and Haverford Mudstone Formation, Slade and Redhill Mudstone Formation, Mydrim Shales Formation and the Llandeilo Flag Formation. Two faults bisect the proposed alignment with another fault running approximately parallel located further south. A large proportion of the site is overlain by Glacial Till of unknown thickness and make-up and there is the potential for alluvial deposits (associated with the watercourse) and made ground (associated with farming activity and the construction of the A40).

A Features and Constraints plan summarising the underlying geology and noting the features described within this report is presented in the Appendices. Quarrying of the underlying bedrock was extensive in the area.

Preliminary engineering assessments based on available information are included in this report. Geotechnical risks identified at this early stage of the project are presented in the geotechnical risk register which can be found in the Appendices.

An intrusive ground investigation has been recommended in Annex A in order to investigate the underlying ground conditions and to determine geotechnical parameters required for the design of any proposed earthworks and structures.

1 Introduction

1.1 Scope and Objective of this Report

1.1.1.1 The Welsh Government appointed Carillion with Arup as their technical advisor to develop the design of the A40 Llanddewi Velfrey to Penblewin Road Improvement. The purpose of the scheme is to improve the single carriageway into a 2+1 configuration.

1.1.1.2 A Preliminary Sources Study Report has previously been prepared by Mott MacDonald [1] for the main length of the scheme between Llanddewi Velfrey to the east and Penblewin to the west. This report forms the Supplementary Preliminary Sources Study Report – prepared for the 1.2km length of scheme to the west of this, that will run between Penblewin Road roundabout and Redstone Cross junction.

1.1.1.3 The geotechnical aspects of this commission will be undertaken in accordance with DMRB Standard HD22/08, Managing Geotechnical Risk [2] and HD22/08: Managing Geotechnical Risk Implementation Guidance – Wales [3]. The objective is to identify and properly manage the geotechnical risks associated with the project. The scheme has been classified as Category 2 in accordance with the guidelines stipulated in HD22/08 [2] (see Section 1.3).

1.1.1.4 This Preliminary Sources Study Report (PSSR) forms part of the process of Geotechnical Certification for the scheme and is produced in accordance with HD22/08 [2] and the Implementation Guidance for Wales [3] and will:

1. Collate and summarise desk study information relating to the site;
2. Identify potential geotechnical and geo-environmental hazards associated with the site; and,
3. Provide a recommendation on proposed site investigation.

1.1.1.5 The sources consulted as part of the study are detailed along with their findings as are observations made during the offline site walkover. An online site walkover will be completed prior to the proposed ground

investigation commencing on site. This will be discussed in the subsequent Ground Investigation Report.

1.1.1.6 A preliminary engineering assessment has been made, which includes analysis of the geotechnical risks and proposals for ground investigation.

1.2 Background

1.2.1 Site Description

1.2.1.1 The A40 forms the key link road between south-east Wales and Haverfordwest and in turn the ports of Fishguard and Milford Haven in addition to connecting central and north Pembrokeshire.

1.2.1.2 The Welsh Government has appointed Carillion to develop the design of a proposed 1.2km section of the A40 Improvements between two existing junctions of the A40: Penblewin Roundabout and Redstone Cross junction.

1.2.2 Context

1.2.2.1 The need for the improvement of the A40 arose in December 2004 when the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study came about as a result of a number of previous reports that all concluded that the A40 needed improvement.

1.2.3 Background

1.2.3.1 In December 2004 the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvements would use the 2+1 configuration allowing overtaking on the two lane direction, prohibited in the one lane direction and would be delivered in the following phases:

1. A40 Penblewin – Slebech Park
2. A40 Llanddewi Velfrey – Penblewin.

1.2.3.2 The first of these projects, Penblewin – Slebech Park, was completed in March 2011.

1.2.3.3 In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

"Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements."

1.2.3.4 On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary:

"In terms of transport links, I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey."

1.2.3.5 In June 2015, in a written statement on the A40 Improvement Study the Minister noted *"It is my intention to progress delivery of the A40 Llanddewi Velfrey to Penblewin scheme as soon as possible…"*

1.2.4 The Reason for the Scheme

1.2.4.1 The reason for the scheme has been determined through consultation with key stakeholders, including the Local Authority, Welsh Government Departments and the Regional Transport Planner through the development of the scheme. The main problems identified are:

1. Limited overtaking opportunities which lead to poor journey time reliability and driver frustration, risky manoeuvres and collision incidents.
2. Inconsistency in the level of overtaking provision between the eastbound and westbound directions. Existing provision gives a total of 5.5km in the westbound direction and 3.2km in the eastbound, amounting to some 13% of the total 32.5km length which remains well below the 30% ratio advised for this type of route.
3. Where overtaking provision does exist it is currently not spread along the length of the A40 and as such there are long lengths in each direction with no overtaking opportunities. This is the case

for vehicles travelling east for at least 19km from Robeston Wathen towards St Clears roundabout and for vehicles travelling west for 9.5km from Canaston Bridge to Haverfordwest roundabout.

4. Occasional convoys of heavy goods vehicles from the ferry ports and slow moving agricultural vehicles, both of which contribute to periods of platooning and journey time unreliability when combined with limited overtaking opportunity.
5. Seasonal spikes in traffic volumes along the A40 and during the summer months. This leads to slow moving tourist traffic causing journey time unreliability when combined with limited overtaking opportunity.
6. Community severance at Llanddewi Velfrey via the current A40 alignment itself.
7. Conflict between vehicle traffic and Non-Motorised Users, particularly along sections where footways are sub-standard.
8. Sub-standard sections of existing road, especially at Llanddewi Velfrey.
9. Numerous side road junctions and the high number of direct accesses to property and fields.
10. A mix of traffic types using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents.
11. A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.

1.2.5 Scheme objectives

1.2.5.1 A number of transport planning objectives have been developed iteratively during previous development work and engagement on the A40 project, aimed to address one or more of the identified problems. During the early stages of Key Stage 3 the problems and objectives were refreshed during a focused workshop event with key stakeholders to take into account the WelTAG 2017 guidance and Wellbeing of Future Generations (Wales) Act wellbeing goals. The scheme objectives are:

1. To improve health and safety on the road and reduce collisions.

2. To improve the resilience of the A40 as an important trade and tourist route through provision of safe, unambiguous overtaking opportunities in both directions using the wide single 2+1 standard.
3. To improve the cohesiveness of communities on the line of the A40, reducing severance effects and taking traffic out of the village communities.
4. To improve capacity, reliability and journey times along the east-west road corridor as a key gateway into Pembrokeshire for local connectivity, access to services, trade and tourism.
5. To improve regional accessibility and mobility.
6. To improve prosperity through better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard and Milford Haven.
7. To maintain and promote cycling, horse riding and walking and provide opportunities for healthy lifestyles.
8. Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.
9. Deliver a project which offers resilience through minimising future maintenance and disruption to the network.
10. To deliver a scheme that integrates with the local transport network and better connects local communities to key transport hubs.
11. To deliver a scheme which opens up legacy opportunities, delivering health and amenity benefits through opportunities to connect to the wider environment.
12. To improve prosperity through opportunities for skills training and employment for local people.
13. Ensure all of these objectives are met with due consideration given to the impact on the environment and opportunities for enhancement.

1.3 Geotechnical Category of Project

1.3.1.1 The scheme is proposed to be classified as Geotechnical Category 2 which is defined in HD22/08 as “projects which include conventional types of geotechnical structures, earthworks and activities, with no

exceptional geotechnical risks, unusual or difficult ground conditions or loading conditions".

1.3.1.2 This Geotechnical Category shall be verified by the Welsh Government through their appointed Overseeing Organisation Geotechnical Advisor (OOGA).

2 Sources of Information and Desk Study

The following sources of information have been reviewed for this study:

2.1 Existing Reports

2.1.1.1 At this time of writing this report, no geotechnical reports are known to exist for this section of the highway.

2.2 Resources

2.2.1.1 The following resources have been reviewed during the production of this report:

1. Envirocheck Report [4]
2. British Geological Survey Geological Maps
    i. 1:50,000 Solid [5]
    ii. 1:50,000 Drift [6]
    iii. 6 inch County Map [7]
3. British Geological Survey Lexicon [8]
4. British Geological Survey Online Record [9]
5. British Geological Survey Geological Memoir [10]
6. Welsh Government IRIS database [12]
7. Natural Resource Wales online viewer, including Flood Risk and LiDAR data [13]
8. Welsh Government Central Register for Aerial Photography [14]
9. Coal Authority online viewer [15]
10. Review of Mining Instability in Great Britain Regional Atlas [16]
11. Defra Magic map online viewer [17]
12. Zetica UK Unexploded Bombs Risk Map [18]
13. Welsh Government Data Portal – Lle, including LiDAR data for topographical information [19]
14. Costain, Atkins and Cresswell Associates, A40 Trunk Road Penblewin to Slebach Park Improvement Geotechnical Report [21]
15. Thyssen Geotechnical, A40 Robeston Wathen Bypass, Ground Investigation Factual Report [22]

3 Field Studies

3.1 Walkover Surveys

3.1.1 Offline Walkover

3.1.1.1 An offline walkover was undertaken on 23rd March 2017 from the existing A40 alignment from Penblewin Roundabout to Redstone Farm. An online walkover was not possible due to site access constraints.

3.1.1.2 It was observed that the land use was predominantly agricultural and there were large variations in levels across the site, with the land dropping down to the south. Mature tree lines were observed along field boundaries which are likely to cross the proposed alignment. A potential drainage feature was identified to the southwest of Penblewin Roundabout; refer to the features and constraints plan for interpreted location.

Figure 1: Photograph taken during offline site walkover, looking south from existing A40 alignment

3.1.1.3 Limited further information was obtained during this site walkover.

3.1.2 Online Walkover

3.1.2.1 An online walkover is to be undertaken prior to the proposed ground investigation commencing on site and will be reported in the subsequent Ground Investigation Report.

3.2 Previous Ground Investigations

3.2.1.1 A review of the BGS online borehole records [9] shows there to be no existing publically available ground investigation information along or near (within 500m) the proposed scheme alignment.

3.2.1.2 A review of the Ground Investigations and subsequent Geotechnical Report for the A40 Penblewin to Slebach Park Improvement scheme [21] [22] was undertaken. The review identified that the extent of the scheme is approximately 5km west of the Redstone Cross Improvements. Whilst the information does not provide details on site-specific underlying geology, it has been referred to in order to provide a general indication of the materials likely to be encountered, refer to Section X below.

3.2.1.3 At the time of writing this report, no known ground investigations have been undertaken in the immediate vicinity of the proposed alignment.

3.2.1.4 However, a ground investigation has been undertaken as part of the Llanddewi Velfrey to Penblewin roundabout section of the scheme and this is reported in the Ground Investigation Report for that part of the scheme [20][18].

3.2.1.5 No ground investigations have been carried out specifically for the Redstone Cross Improvements section of the scheme.

4 Site Description

4.1 Geography

4.1.1.1 This section of the A40 scheme lies approximately 5km north of Narberth, Pembrokeshire, and links Penblewin roundabout in the east to Redstone Junction in the west.

4.1.1.2 The site is bounded by the Redstone Cross junction to the west, the Penblewin roundabout to the east and fields to the north and south.

4.2 Topography

4.2.1.1 At the time of writing this report, no chainages for the proposed alignment were available.

4.2.1.2 No topographical surveys have been undertaken along the proposed alignment however there is limited historic LiDAR Data [19] available, therefore the topography presented may be influenced by vegetation picked up during the survey.

4.2.1.3 The site lies at approximately 95mAOD at the Penblewin roundabout, which is the eastern extremity of the site, before leaving the current alignment of the A40 to continue in a south westerly direction to cross a valley associated with a watercourse.

4.2.1.4 The land drops steeply to approximately 76mAOD when it reaches the watercourse crossing and then rises gradually to meet the current A40 junction at Redstone Road at the western extremity of the site at a level of approximately 100mAOD.

4.2.1.5 A known watercourse to the south follows an existing tree line which extends to cross the proposed route where the land gradually rises. This may be the continuation of the watercourse or the potential catchment areas of this watercourse.

4.2.1.6 The LiDAR shows no real suggestion of a valley feature associated with watercourse but this historic and limited data may be inaccruate and the potential for an area which may be slightly lower feeding the

southern watercourse might be present and should be investigated during the online walkover.

4.3 Historical Development and Man-Made Features

4.3.1.1 Table 1 below presents a summary of the historical development and man-made features noted in the historical maps included in the Envirocheck Report (Ref. [4]). Aerial photographs have also been reviewed and this is discussed further in Section 4.3.2.

Table 1 Summary of historical development

Map (Date)	Development in the vicinity of the proposed alignment
Pembrokeshire / Carmarthenshire 1:10,560 (1888)	The A40 is shown in its current alignment with buildings shown along the highway at Blackmoor Hill (noted as Cilrath-fâch cottages) and Redstone Cross. Enclosed fields (assumed to be pasture) are shown with the boundaries in the present-day locations. Heathland / rough grassland is shown to the south and the east of the Blackmoor Hill settlement, along the proposed route of the A40. The Afon Marlais is shown to flow west – east from Redstone Cross, south of the proposed alignment. Several quarries and old quarries are noted on the maps, particularly north of the alignment, in the vicinity of Cilrath Wood and between Broomley / Sodstone House. However, none are noted on the existing or proposed alignment of the A40. Several springs and wells are noted in the area with the closest well to the existing and proposed alignment shown immediately south of the Redstone Cross junction.
Pembrokeshire / Carmarthenshire 1:10,560 (1907)	No major change. A spring is noted south of the buildings at Blackmoor Hill Farm and the extent of heathland / rough grassland is shown to be slightly greater than in the 1888 maps. A reservoir is now shown to be located immediately west of Broomley, in the vicinity of springs and old quarries.
Pembrokeshire / Carmarthenshire 1:10,560 (1953)	No major change.
Ordnance Survey 1:10,000 (1964)	No major change. The reservoir which was shown immediately west of Broomley is no longer shown on the map. A caravan park and depot are now shown approximately 1 – 1.5km south of the proposed alignment.

Map (Date)	Development in the vicinity of the proposed alignment
Ordnance Survey 1:10,000 (1974)	No information shown.
Raster Mapping 1:10,000 (2006)	No major changes. Watercourses (mainly drains) are shown on the map. One crosses the proposed alignment at Blackmoor Hill Farm and another is shown further south however this does not cross the alignment. A forge is shown to be located at Redstone Cross junction. Development associated with Narberth is shown over 1km south of the proposed and existing alignment. A small body of water (assumed to be a pond) is shown immediately south of the proposed alignment, east of where it joins the existing alignment at Redstone Junction.
Vector Map Local 1:10,00 (2015)	No major changes.

4.3.2 Aerial Photographs

4.3.2.1 The aerial photographs available at the Welsh Government Aerial Photography Unit were reviewed by a geotechnical engineer on 5th March 2017. The photographs covered the period from 1946 to 2013.

4.3.2.2 These photographs provided no indication of any additional features to those identified from review of the historic plans.

4.3.3 IRIS Database

4.3.3.1 The IRIS database [12] was reviewed for any further geotechnical information pertinent to the scheme. The following entries were reviewed but are considered to have no relevance to the proposed realignment of the route:

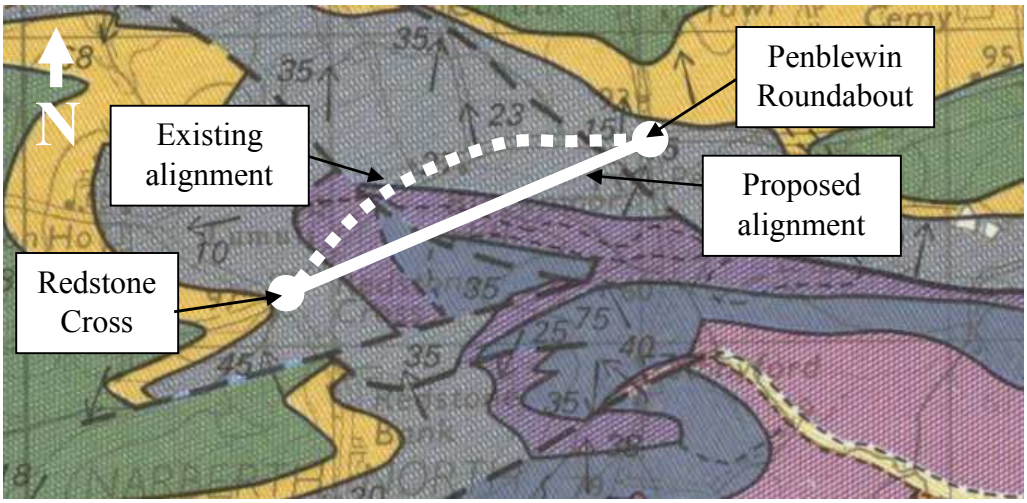
Table 2 IRIS Database Entries

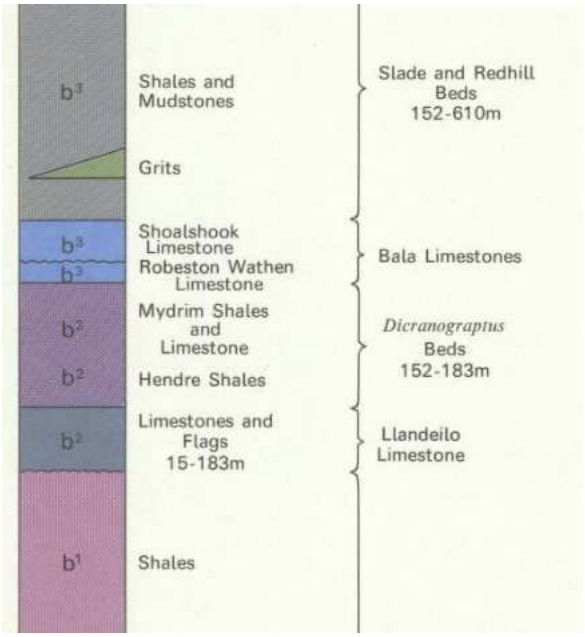
Type of observation	Observation Ref.	Location	Description
Feature	3_A40_1724_9944	Northern extent of existing alignment, opposite Blackmoor Hill Farm	Wall defective due to erosion of soil and invasive vegetation
Feature	3_A40_1721_9930	Southern extent of existing alignment, approximately 150m north east of Redstone Farm	Settlement around manhole

4.4 Geology

4.4.1.1 Extracts from the British Geological Survey 1:50,000 geological maps showing both underlying solid [5] and drift geology [6] are presented below.

4.4.2 Solid Geology





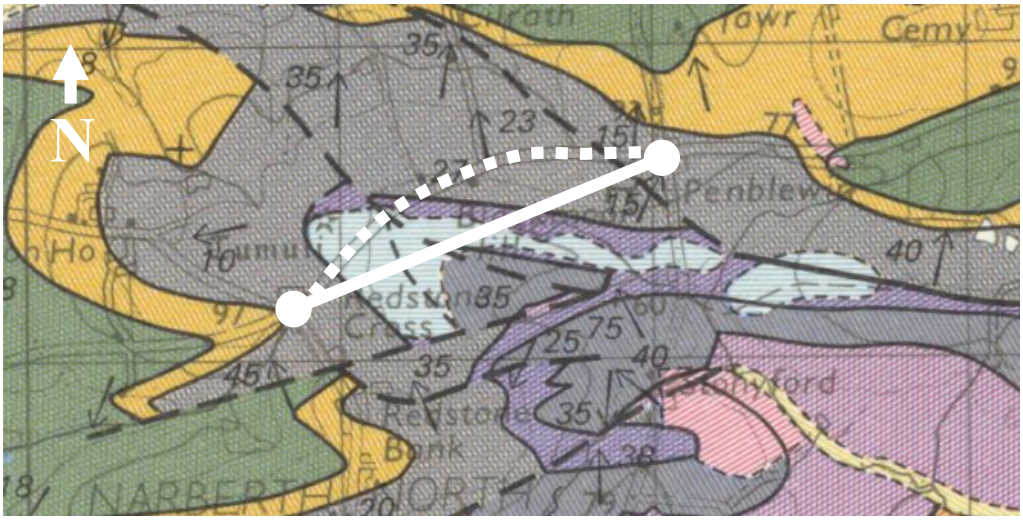
C08/006-CLSCSL British Geological Survey ©NERC. All rights reserved. © crown copyright.

Figure 2 Extract from BGS 1:50,000 Geological Map, Sheet 228 (Havorfordwest), Solid

4.4.2.1 The proposed alignment is shown to cross over two faults: the most easterly bisecting the road at approximately 80 degrees and the most westerly at around 45 degrees.

4.4.2.2 The dip of the underlying bedrock is shown to vary considerably in both direction and dip angle which suggests the underlying bedrock is folded, as well as faulted across the site.

4.4.3 Superficial Deposits



C08/006-CLSCSL British Geological Survey ©NERC. All rights reserved. © crown copyright.

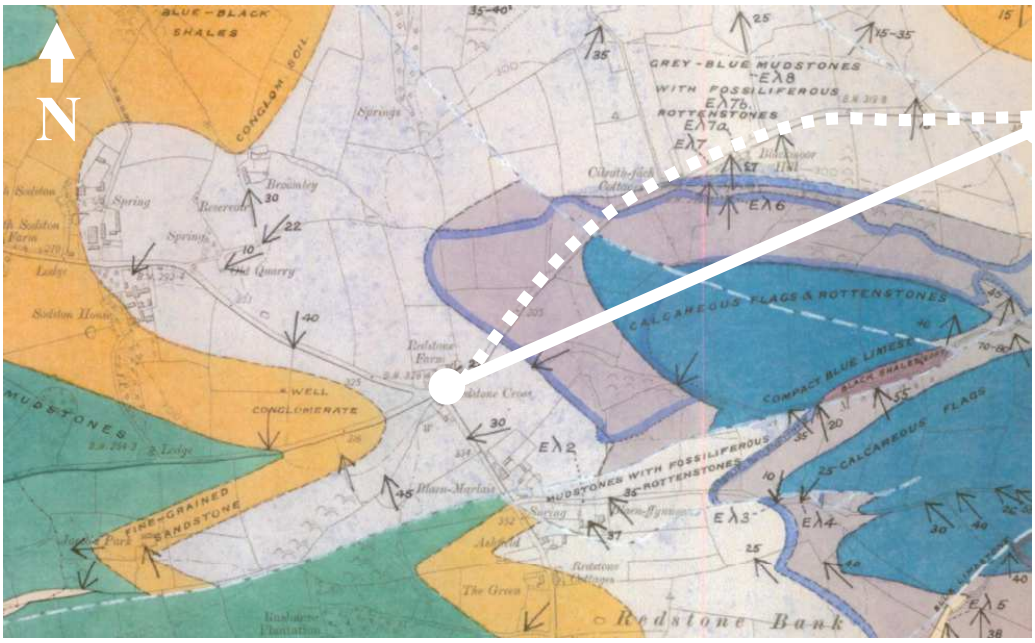
Figure 3 Extract from BGS 1:50,000 Geological Map, Sheet 228 (Havorfordwest), Drift

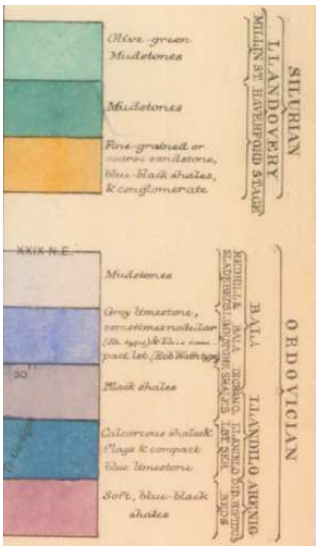
4.4.3.1 The central section of the proposed route is shown to be underlain by Glacial Till, the make-up, thickness and exact extent of which is unknown.

4.4.3.2 No alluvial deposits are shown on the geological maps but these are likely to be present due to the watercourse crossing the proposed route.

4.4.3.3 Although the site appears relatively undeveloped apart from agricultural industry, there is the potential for Made Ground to be encountered. Particularly as there are numerous historic quarries in the local vicinity, some of which may have been infilled.

4.4.3.4 An extract of the 6 inch County Geological Map [7] is presented below.





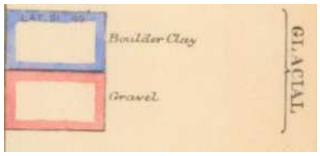


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Figure 4 Extract from BGS 6 inch County Geological Map,

4.4.3.5 This generally agrees with the more recent maps shown above but provides some more detail regarding bedding dip angles and directions.

4.4.3.6 The BGS Maps show the site to be underlain by the following solid geology. As these materials have been regrouped and renamed a number of times, Table 6 below summarises the name changes and regrouping of these strata from the various geological resources reviewed.

Table 3 Strata Terminology within the Haverfordwest area reproduced from Cocks and Price, 1975 [11], and supplemented with geological sequence from the 1:50,000 geological plans [4] [5]

<table>
<tr><th>Name from Strahan et al, 1914 (referenced in Cocks and Price)</th><th colspan="3">Name from 1:50,000 Geological Plan</th><th>Name from Cocks and Price</th><th>Name to be used in this report</th><th></th></tr>
<tr><td>Gasworks Sandstone</td><td rowspan="4">Haverford Beds</td><td colspan="2">Gasworks Sandstone</td><td>Gasworks Sandstone Formation</td><td>(Absent in this area)</td><td rowspan="11">Not shown to underlie the site
Shown to underlie the site (unless otherwise noted to be absent)</td></tr>
<tr><td>Gasworks Mudstone</td><td colspan="2">Gasworks Mudstones</td><td rowspan="2">Haverford Mudstone Formation</td><td rowspan="3">Portfield Formation and Haverford Mudstone Formation – undifferentiated</td></tr>
<tr><td>Cartlett Beds</td><td colspan="2">Cartlett Beds</td></tr>
<tr><td>Basement Beds</td><td colspan="2">Cethings Sandstone, Black Shales and Conglomerates</td><td>Portfield Formation</td></tr>
<tr><td>Slade and Redhill Beds</td><td rowspan="4">Bala Series</td><td colspan="2">Slade and Redhill Beds</td><td>Slade and Redhill Mudstone Formation</td><td>Slade and Redhill Mudstone Formation</td></tr>
<tr><td rowspan="4">(Not referenced)</td><td colspan="2">Bala Limestones</td><td rowspan="4">(Not referenced)</td><td>(Absent in this area)</td></tr>
<tr><td>Mydrim Shales and Limestone</td><td rowspan="2">Dicranograptus Beds</td><td>Mydrim Shales Formation</td></tr>
<tr><td rowspan="2">Llandeilo Series</td><td>Hendre Shales</td><td>(Absent in this area)</td></tr>
<tr><td colspan="2">Llandeilo Limestone</td><td>Llandeilo Flags Formation</td></tr>
</table>

4.4.3.7 Note that for the completeness of the geological strata, the Gasworks Sandstone Formation and Gasworks Mudstones Formation are included above but these are not shown to underlie the site. The geological maps also suggest that the Bala Limestones and Hedre Shales are absent from this area.

4.4.3.8 It should be noted that the data displayed by the BGS web viewer [9] does not correspond to the 1:50,000 geological plans [5] [6], the geological sheet memoir [10] and the Cocks and Price publication [11]. The discrepancies identified on the BGS web viewer [9] and Lexicon [8] are summarised below:

- The Haverford Mudstone Formation is referred to as the 'Portfield Formation' on the BGS web viewer.
- The accompanying Lexicon entry for the 'Portfield Formation' appears to be the information relevant to the underlying Portfield and Haverford Mudstone Formation.
- The Lexicon entries for the following formations are mostly blank:
    - Portfield and Haverford Mudstone Formation;
    - Slade and Redhill Mudstone Formation;
    - Mydrim Shales Formation; and,
    - Llandeilo Flags Formation.

4.4.3.9 As recorded in the Ground Investigation Report for the main part of the A40 [20], Arup contacted the BGS in regards to the potential errors in the web viewer and Lexicon and for clarification on the names of the formations. The BGS have acknowledged that there appears to be errors in the naming of the formations and indicated that the names of the formations as presented in the Ground Investigation Report, and hence in this Preliminary Sources Study Report, are correct. The BGS indicated that the web viewer and Lexicon would be updated, but could not confirm a date when this would be completed.

4.4.3.10 Further descriptions of the sub-division of each formations is provided below.

Portfield and Haverford Mudstone Formation

4.4.3.11 The Cethings Sandstone, Black Shales and Conglomerates have a thickness of approximately 70m. In the memoir [8], these are characterised by "*black shales and black flaggy"* mudstones. Locally in the lower part are the Basal Conglomerates and in the upper part the Cethings Sandstone. The Basal Conglomerates are described as "*coarse conglomerate"* up to 30m in thickness. The Cethings Sandstone is described as "*a fine-grained grey sandstone*" overlain by

"*soft blue-black shales which on weathering display an orange and vermilion surface-staining*".

Slade and Redhill Formation

4.4.3.12 The Shales and Mudstones from the Slade and Redhill Formation have thicknesses ranging from 152m to 610m [1]. The Redhill Beds are described as "*sharped-based sandstones with basal shell lags and bioturbated tops, interbedded with grey, silty mudstones*" whilst in the overlying Slade Beds, "*the frequency and thickness of these beds is greater and the associated mudstones are more fossiliferous*" [11]. These two beds have been grouped into a single formation due to the vague boundary region between the two beds [11]. Slade and Redhill Beds of the 'southern type' beneath the scheme are described as "*blue-grey mudstones, with frequent thin bands of brown to grey micaceous sandstone and highly calcareous layers weathering to a brown sandy rottenstone*". The memoir [10] records these to be present in the western end of the scheme at Penblewyn where they are indicated to be approximately 110m in thickness, of which around 90m is made of the Slade.

Mydrim Shales Formation

4.4.3.13 The Mydrim Shales Formation is described as "*somewhat rubbly dark-grey pyritous shales in their lower part, but towards their upper limit become more evenly bedded*". To the south of the cottages on Blackmoor Hill, a thickness of 250 feet has been estimated for this stratum. It is noted that they are "*overlain by calcareous sandy beds which are exposed in the well that supplied the cottages*". The location of this well is marked as a spring (as per the historic maps) at Blackmoor Hill on the Features and Constraints Plan.

Llandeilo Flags Formation

4.4.3.14 The Llandeilo Flags Formation near Narberth are described as *"fossiliferous sandy calcareous flags"* which are then followed by *"massive dark-blue sparsely-fossiliferous limestones weathering to a yellow-brown rottenstone"*. It is noted that in the north of Narberth the

thickness of the series is about 250 feet and has been extensively quarried.

4.4.3.15 The following superficial deposits are shown on the geological plan or are likely to be encountered underlying the site. Descriptions are from the BGS lexicon [8].

Glacial Till	*"Group of sediments laid down by the direct action of glacial ice. Variable lithology, usually sandy, silty clay (possibly chalky in southeast England) with pebbles, but can contain gravel-rich, or laminated sand layers; varied colour and consistency."*
Alluvial Deposits (associated with the watercourse)	*"Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated zone may be present."*
Glaciofluvial Deposits (noted 1km south of the proposed alignment)	*"Sand and gravel, locally with lenses of silt, clay or organic material; of glaciofluvial origin."*

4.4.3.16 A review of the BGS memoir [10] has not provided any further detail in the descriptions of the superficial deposits likely to be encountered underlying the site.

4.4.3.17 The Ground Investigation Report for the main scheme [20] identifies the presence of the superficial deposits as listed above. However, the Ground Investigation undertaken to date has not targeted these deposits.

4.4.3.18 The Glacial Till covers a large proportion of the site, the thickness and make-up of which is unknown. The geological map shows areas of glacial till to the west of the scheme which have been investigated as part of the A40 Trunk Road Penblewin to Slebach Park Improvement Ground Investigation [21] [22]. These were described as *"generally of grey to brown coloured gravel, with often a significant proportion of silt and clay and also with some cobbles and few boulders"*. However, this description relates to the deposits encountered up to 10km to the

west of the scheme and therefore cannot be relied upon to be representative of the Glacial Till encountered on this scheme.

4.4.3.19 The Glacial Till deposits shown to be on site appear to be related to the alignments of the two minor watercourses, one of which crosses the scheme alignment. This suggests that there is the potential for features associated with the deposition of infilled buried channels to run though the deposits.

4.4.3.20 The identified geologies are shown on Drawings A40LVP-ARP-VGT-M02-DR-C-0001 (Features and Constraints Plan).

4.4.4 Geomorphology

4.4.4.1 The topography of the area with valley features and watercourse, as well as presence of glacial till indicates the area has been affected by glaciation.

4.4.5 Ground Hazards

4.4.5.1 The Envirocheck report [4] presents the following ground hazards and associated risk levels:

Table 4 Summary of Ground Hazard and Associated Risk Level

Ground Hazard	Risk Level	Details
Potential for collapsible ground stability hazards	Low	
Potential for compressible ground stability hazards	Moderate	Noted 1km north and 600m south of the proposed alignment. This is assumed to be related to the potential for alluvium associated with the water courses on site.
Potential for running sand ground stability hazards	Low	
Potential for landslide ground stability hazards	Low to very low	
Potential for ground dissolution stability hazards	None	
Shrinking or swelling clay ground stability hazards	Very low	

4.5 Hydrology

4.5.1.1 The Natural Resource Wales flood record [13] shows a low risk of flooding from rivers in the immediate vicinity of the watercourse crossing the site.

4.5.1.2 The following watercourses presented in Table 5 were noted within 100m of the proposed alignment. Further details of watercourses located further than 100m from the proposed alignment can be found in the Envirocheck report [4]. These watercourses are also presented on the Features and Constraints plan.

Table 5 Summary of known watercourses within 100m of the proposed alignment

Watercourse Name	Type	Estimated distance from site (m)	River Flow Type	River Surface Level	Drain Feature
Unknown	Tertiary river	0	Primary flow path	Surface	Not a drain
Unknown	Tertiary river	0	Primary flow path	Surface	Not a drain
Drain	Tertiary river	58	Primary flow path	Surface	Drain
Unknown	Tertiary river	81	Primary flow path	Surface	Not a drain
Unknown	Tertiary river	100	Primary flow path	Surface	Not a drain

4.5.1.3 The following water sources presented in Table 6 were noted within 100m of the proposed alignment and are shown on the Features and Constraints plan.

Table 6 Summary of known water sources within 100m of the proposed alignment

Details	Estimated distance from site (m)
Well	17 South
Pond	23 East
Pond	77 North-East

4.5.1.4 As detailed in Section 4.9, the presence of ponds highlights the potential for unknown historic quarrying and other extractive industries in the immediate vicinity which have since been infilled.

4.5.1.5 Several springs are noted on the historic maps and these are shown in the Features and Constraints plan in Appendix A.

4.6 Hydrogeology

4.6.1.1 The Envirocheck Report [4] shows the site to predominantly be underlain by Secondary B aquifers apart from the Llandeilo Flags Formation which is designated a Secondary A aquifer. These designations are defined by Natural Resource Wales [13] as follows:

Secondary A *"Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flows to rivers. These are general aquifers formerly classified as minor aquifers."*

Secondary B *"Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers".*

4.6.1.2 Glacial till is shown to be an unproductive stratum in terms of groundwater.

4.6.1.3 There are no source protection zones or sensitive land uses within 1km of the proposed alignment.

4.7 Land Designations

4.7.1.1 The DEFRA Magic map online viewer [17] shows that no statutory or non-statutory designated sites lie in the vicinity of the proposed scheme.

4.8 Mining and Quarrying

4.8.1.1 Records of mines and mineral deposits have been reviewed from the Review of Mining Instability in Great Britain [16] for metalliferous mining (non-ferrous), rock mining, coal mining (and associated minerals), iron mining (non-coalfield) and evaporite mining, and show the site to be outside of any of the areas known for the extractive industries listed above.

4.8.1.2 The Coal Authority online viewer [15] shows the site to lie outside any known areas of coal mining activity.

4.8.1.3 No records of mines or mineral deposits have been identified for the scheme area in the above sources. However, a number of quarries and gravel pits have been identified which are shown on the Features and Constraints plan.

4.8.1.4 Table 7 below summarises the known BGS mineral sites with 500m of the proposed alignment. The locations of these are presented in the Features and Constraints plan. Further details of sites located further than 500m from the proposed alignment can be found in the Envirocheck report [4].

Table 7 Summary of BGS mineral sites within 500m of the proposed alignment

Site Name	Type	Status	Operator	Geology	Commodity	Estimated distance from Site (m)
Rushacre Farm	Opencast	Active	Mr G. James	Portfield formation and Haverford Mudstone Formation (undifferentiated)	Common clay and shale	308 South
The Green	Opencast	Ceased	Unknown	Slade and Redhill Formation	Common clay and shale	320 South-East
Broomley	Opencast	Ceased	Unknown	Slade and Redhill Formation	Common clay and shale	354 North-West
Redstone Cottages	Opencast	Ceased	Unknown	Portfield formation and Haverford Mudstone Formation (undifferentiated)	Sand and gravel	435 South-East

4.8.1.5 Table 8 below summarises the number of known historic mineral sites and potentially infilled land within 250m, 500m and 1km of the proposed alignment:

Table 8 Summary of historic mineral sites and potentially infilled land within 1km of the proposed alignment

Type	Number of sites within 250m of site	Number of sites within 500m of site	Number of sites within 1km of site
General Quarrying	0	3	3
Quarrying of sand and clay, operation of sand and gravel pits	0	1	3
Potentially infilled land (non-water)	0	3	4
Potentially infilled land (water)	2	2	4

4.8.1.6 The locations of these are presented in the Features and Constraints plan.

4.8.1.7 There is the potential for unknown historic quarrying and infilled land in the vicinity of the alignment with the associated risk of contamination if these have been infilled.

4.9 Potential for Contamination

4.9.1.1 A summary of present-day industry, which included a review of the Lle website [19], within 500m of the proposed alignment is presented in Table 9 below.

4.9.1.2 Further details of present-day industry located further than 500m from the proposed alignment can be found in the Envirocheck report [4].

Table 9 Summary of Industries within 1km of the proposed alignment

Name	Classification	Status	Estimated distance from Site (m)
Redstone Forge Garage	Garage services	Inactive	2 South-East

4.9.1.3 A provisional search shows the garage is likely to be a repair workshop without fuelling activities therefore the potential for

contamination is likely to be predominantly localised spillages. This is unlikely to impose a significant risk.

4.9.1.4 The location and nature of this business should be confirmed during the online site walkover.

4.9.2 Land Use and Soil Survey Information

4.9.2.1 The study area is in a rural setting and comprises agricultural land, grazing pastures and local landowner properties.

4.9.2.2 A provisional search shows no farm buildings to be on the proposed realignment however there are three farms along the present-day alignment: Pen-blewin Farm, Blackmoor Hill Farm and Redstone Farm.

4.9.2.3 The potential sources of contamination include localised spillages from farming machinery, fuel storage or waste storage. This is unlikely to impose a significant risk.

4.9.2.4 The historical maps show that the existing A40 has been aligned approximately along the present day alignment since before 1888.

4.9.2.5 There is the potential to encounter Made Ground associated with the construction of the A40 although this is unlikely to pose a significant risk.

4.10 Unexploded Ordnance

4.10.1.1 The UK Unexploded Bombs (UXB) risk map [18] shows the site with a low risk of unexploded ordnance.

5 Ground Conditions

5.1.1.1 The following ground conditions are expected to be encountered on site. Further details can be found in Section 4.4 of this report and within the Ground Investigation Report for the Llanddewi Velfrey to Penblewin length of the scheme [20].

5.2 Superficial Deposits

5.2.1.1 The following superficial deposits are anticipated to be encountered on site:

1. Made Ground – associated with historic quarrying activities and the potential for infilled ground
2. Alluvium – associated with the watercourse crossing the proposed alignment
3. Glacial Till

5.2.1.2 There is no site-specific investigation of the superficial deposits listed above. Descriptions based on information reviewed is summarised in Section 4.4.3. However, there is need to undertake targeted Ground Investigation which is further detail in Annex A.

5.2.1.3 There is potential for the materials encountered on site to be particularly soft or highly variable and the implication to the engineering of the scheme is further discussed in Section 6.

5.3 Solid Geology

5.3.1.1 The following solid geology is shown to be underlying the site:

1. Portfield Formation and Haverford Mudstone Formation (undifferentiated)
2. Slade and Redhill Formation
3. Mydrim Shales Formation
4. Llandeilo Flags Formation

5.3.1.2 The main section of the scheme is underlain by the Portfield Formation and Haverford Mudstone Formation and the Slade and Redhill Formation.

5.3.1.3 General descriptions of the strata from the BGS memoir [10] for the Portfield Formation and Haverford Mudstone Formation and the Slade and Redhill Formation are provided in Section 4.4.

5.3.1.4 The Ground Investigation Report [20] states that "no clear significant differences between the different formations have been identified, other than variations between the different rock types and the degree of weathering… No distinguishable trends relating to specific formations have been identified. On this basis, for the purpose of the engineering interpretation within this report, it is proposed to not distinguish between the different geological formations and to only distinguish between the different rock types. Mudstone is the most prevalent rock type within the scheme, but areas and bands of sandstone, conglomerate and siltstone have also been encountered".

5.3.1.5 The Mydrim Shales Formation and Llandeilo Flags Formation do not underlie the main scheme and there is no information on these strata in this document. However, these strata have been encountered as part of the A40 Trunk Road Penblewin to Slebeach Park Improvement scheme [21] [22].

5.3.1.6 General descriptions of the strata from the BGS memoir [10] for the Mydrim Shales Formation and the Llandeilo Flags Formation are provided in Section 4.4.

5.3.1.7 The A40 Trunk Road Penblewin to Slebeach Park Improvement scheme [21] [22] also does not differentiate between the different strata. It describes the underlying solid geology as "grey to black, mudstone and siltstones, with occasional thin, fine sandstone beds. At the eastern end of the scheme some limestone and calcareous mudstone were encountered. The rock was weathered to brown and occasionally orange brown".

5.4 Groundwater

5.4.1.1 Known springs and wells are presented on the Features and Constraint plan in Appendix A.

5.4.1.2 There is no further information in relation to groundwater level across the site, however groundwater levels are anticipated to be high in low lying areas and adjacent to watercourses.

6 Preliminary Engineering Assessment

6.1 General

6.1.1.1 A preliminary engineering assessment has been undertaken using the available information for the proposed alignment. Pertinent considerations are presented in the following sub-sections.

6.1.1.2 Limited reliable information is available for the topography of the area and therefore the scope of earthworks likely to be required but these have been estimated for the purposes of this report. Further topographical surveys are required for development of the design of the scheme.

6.1.1.3 Information relating to the underlying material is predominantly based on geological maps and descriptions from the available geological memoirs. The site-specific properties of these materials have not been investigated and a ground investigation is proposed to identify the ground conditions and establish relevant geotechnical parameters. The scope of the proposed ground investigation is presented in 0.

6.2 Cuttings

6.2.1.1 The proposed cuttings are estimated to be up to approximately 2m in depth and located at existing high points in the existing topography. This will be confirmed during preliminary design.

6.2.1.2 The following points should be considered during preliminary design:

1. Excavated material – it is envisaged that the majority of the excavated material is likely to be of varying degrees of weathered rock (mudstones and limestones) and limited amounts of Glacial Till. For the shallow depths of cutting envisaged, down to 2m, it is possible that a reasonably high proportion of the excavated materials could be predominantly made up of superficial deposits and weathered rock, as opposed to unweathered rock.
2. Given that the shallow cuttings will either be in what is likely to be reasonably highly weathered rock, or in glacial till materials, it is reasonable to anticipate at this stage that shallower angles may be required.

3. Should deeper excavations into less weathered rock be proposed, steeper angles are likely to be possible, however there is the possibility that unfavourable bedding planes and discontinuities may be present. There is therefore the risk that supplementary stabilisation measures may be required for any rock cuttings – such as rock bolting or rock anchoring.
4. Given the shallow depths of cutting envisaged, it is unlikely that any specific slope drainage measures will be required. Surface water drainage measures will however be required, which are likely to comprise open channels at the crest where the adjacent ground falls towards the cutting, and combined road drainage and groundwater filter drains at the toes of cutting slopes.

6.3 Embankments

6.3.1.1 The proposed embankments are likely to be up to 15m in height at the centre line, and potentially greater from toe to crest due to the sloping nature of the topography. This will need to be confirmed during preliminary design.

6.3.1.2 The following points should be considered during preliminary design:

1. Superficial deposits including Alluvium and Glacial Till are likely to be present in the low spots in the topography, which would form the foundation materials for the proposed embankments. Subject to the thickness of these deposits and their composition – in terms of strength and stiffness – there is the potential for deep seated instability and relatively high magnitudes of total (and differential) settlement, particularly considering the relatively large embankments that are proposed. Should instability or settlement be an issue excavation and replacement of superficial deposits may be an option, as long as they are of limited thickness, with the embankments founded on the underlying rock, or other competent material (see Section 6.5.1.3) which should provide a suitable founding stratum.
2. Based on the information collated for this desk based study, the majority of excavated material from the cuttings is likely to be suitable for re-use, but may require some treatment, e.g. drying out of “wetter” materials excavated from shallow depth (see Section 6.2.1.2). It is likely that following processing and/or treatment this material will meet the acceptable limits of either Class 1 or Class 2

general fill as defined in Series 600 of the Specification for Highways Works [23].

6.4 Subformation

6.4.1.1 No CBR testing or other location specific ground investigation has been completed.

6.4.1.2 Where cuttings are proposed they are likely to be into glacial deposits or the underlying weathered rock. On the basis of the desk based study, it is anticipated that CBR values of around 3 – 5% may be achievable for these formations. These values are in general agreement with the results from the Ground Investigation for the main scheme [20] and shall be confirmed during the site-specific Ground Investigation. Should competent non-argillaceous rock be encountered, high values – possibly in excess of 15% – could be achievable.

6.4.1.3 Where embankments are proposed there will be the opportunity for the final layers up to formation level to be carefully selected to provide favourable CBR values. There may be the opportunity to construct an 'improvement layer' with CBR values in excess of 15%. However, this will be dependent on the availability and nature of appropriate material either derived from the scheme or imported from local resources.

6.4.1.4 Where the alignment is to be constructed at-grade, the subformation CBR value will be governed by the shallow superficial deposits or weathered rock that is present at the ground surface. The nature of this material is not currently known, but it is anticipated that weathering and softening will have occurred, and CBR values of less than 5% may be applicable. There is a risk that values of less than 2.5% may be applicable which may result in the need for localised improvement. Further investigation is therefore recommended to inform this uncertainty.

6.5 Structural Foundations

6.5.1.1 Preliminary review of the proposed alignment indicates that a culvert is required at the crossing of the watercourse. The size of this culvert

has not been assessed at this stage, this shall be confirmed during preliminary design.

6.5.1.2 The potential for an area to be slightly lower and linked to the watercourse to the south of the proposed route is to be investigated during the online walkover and may result in the requirement for an additional culvert in order to prevent any potential damming of the potential catchment area.

6.5.1.3 It is envisaged that shallow foundations are likely to be appropriate. However, if significant depths, or particularly soft superficial deposits are present at the structure location, large magnitudes of total and differential settlement may result. Should this be the case, localised excavation down to rock or an alternative competent formation, and replacement with suitable fill, may be required.

6.6 Contaminated Land / Soil Chemistry

6.6.1.1 The potential for contaminated land is envisaged to be low due to the rural nature of the surrounding land. Whilst no historic roads, buildings or developments have been identified along the scheme alignment, there is a risk that unidentified contaminative features are present, such as areas of made ground and infilled quarries.

6.6.1.2 A comprehensive site walkover is to be undertaken by a geotechnical / geo-environmental engineer once land access is available. This shall further inform the possible presence of potential contamination. Appropriate geo-environmental sampling and testing should be undertaken as part of the ground investigation. This will enable more detailed assessments to be carried out, which shall be reported in the Ground Investigation Report.

6.6.1.3 The potential for aggressive ground conditions to be present, in particular the presence of elevated sulphates, total potential sulphates and low pH values, shall be investigated as part of the proposed ground investigation. There is the risk that high sulphides and pyritic

conditions may be present due to the presence of mudstones which are susceptible to such conditions.

6.7 Existing Geotechnical Problems

6.7.1 Slope failures

6.7.1.1 There are no known slope failures within the existing topography along the proposed alignment. However, this should be confirmed during the proposed site walkover.

6.7.2 Mineworkings and quarrying

6.7.2.1 The Coal Authority [15] shows the proposed alignment to not be within a known coal mining area.

6.7.2.2 There is a history of rock quarrying in the local vicinity, some of which could be infilled. There is therefore a risk that unidentified, infilled quarries may be present along the scheme alignment.

6.7.3 Very Soft / Highly Compressible Soils

6.7.3.1 A review of the desk study information shows a low to very low risk of solution features along the proposed alignment.

6.7.3.2 There is the potential for soft, compressible alluvial deposits associated with the watercourse known to cross the site as well as the presence of Glacial Till on the site, which could be variable and soft in parts.

6.8 Effect of Man Made Obstacles / Site History

6.8.1.1 Burnt mounds have been recorded around the scheme area. Further archaeological investigation is proposed, and the precise location of any known features is to be determined prior to commencement of any intrusive ground investigation works. If any are encountered, they may require protection depending on the recommendations of the archaeological surveys.

6.8.1.2 Two tumuli are noted immediately north of the present day alignment of the A40 and are noted as scheduled monuments [19]. As the proposed realignment runs to the south of the present day alignment, these scheduled monuments will not be disturbed.

7 Comparison of Project Options and Risks

7.1.1.1 From the information obtained, the following potential geotechnical and geo-environmental hazards associated with the site and the surrounding area have been identified:

1. Potential for infilled land – due to the historic quarrying in the area, there is the potential to encounter potentially contaminated material used to backfill the quarries.
2. Potential for excessive settlements of proposed earthworks and structures – part of the proposed alignment is underlain by Glacial Till of unknown make-up. Two areas potentially underlain by alluvial deposits associated with two watercourses will be crossed by the proposed alignment. Historic quarries may also have been infilled by poorly compacted material.

7.1.1.2 Further geotechnical risks are presented in the geotechnical risk register which is included in Appendix B.

8 Drawings and Photographs

8.1.1.1 The following photographs were taken during the offline site walkover in March 2017.

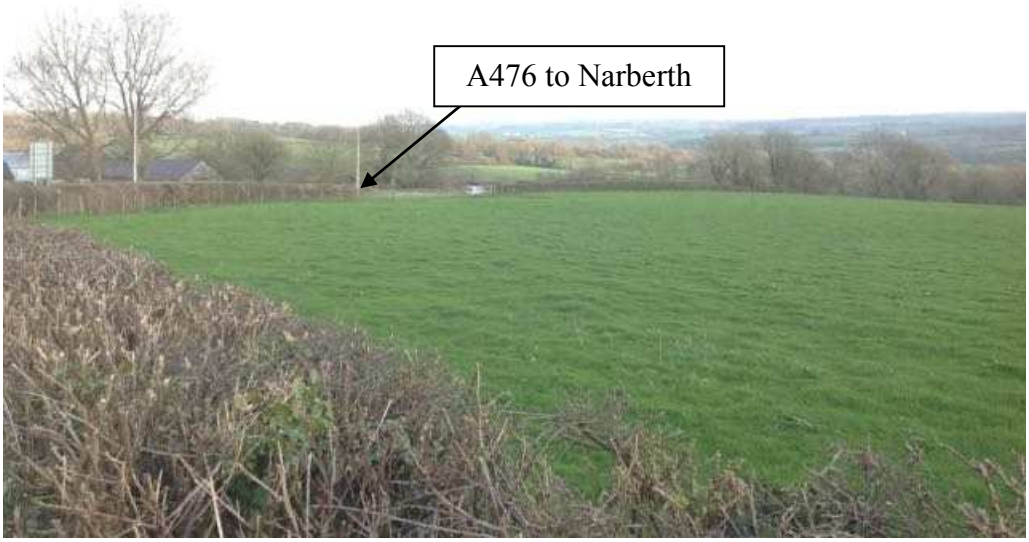

Figure 5 Photograph taken from Penblewin Roundabout looking South

Figure 6 Photograph taken from Penblewin Roundabout looking South-West

Figure 7 Photograph taken from the existing A40 alignment, West of Penblewin Roundabout looking South

9 References

[1] Mott MacDonald, Preliminary Sources Study Report, Revision A (2016)

[2] Highways England, Design Manual for Roads and Bridges, HD22/08, Volume 4, Section 1, Part 2, Managing Geotechnical Risk (August 2008)

[3] Highways England, Design Manual for Roads and Bridges, HD22/08: Managing Geotechnical Risk Implementation Guidance - Wales (December 2009)

[4] Envirocheck Report, Site at St Clears / Sancler, Reference 358432 (November 2015)

[5] British Geological Survey Map Sheet 228 (1:50,000 solid) Haverfordwest (1976)

[6] British Geological Survey Map Sheet 228 (1:50,000 drift) Haverfordwest (1976)

[7] British Geological Survey 1:10,560 county map, Pembrokeshire sheet XXIX NW, 2nd Ed. (1907)

[8] British Geological Survey Lexicon of Named Rock Units. Available at http://www.bgs.ac.uk/lexicon/. (Accessed in March 2017)

[9] British Geological Survey Online Record. Available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html . (Accessed in March 2017)

[10] Memoir of the Geological Survey Sheet 228, The Geology of the South Wales Coalfield, Part XI, the Country around Haverfordwest (1914)

[11] The biostratigraphy of the upper Ordovician and lower Silurian of south-west Dyfed, with comments on the Hirnantia fauna, L. R. M. Cocks and D. Price. (1975)

[12] Welsh Government, Integrated Roads Information System. (Access in April 2017)

[13] Natural Resources Wales Website. Available at https://naturalresources.wales/ . (Accessed in March 2017)

[14] Welsh Government, Central Register for Aerial Photography. (Accessed in April 2017)

[15] The Coal Authority Website. Available at https://www2.groundstability.com/ . (Accessed in March 2017)

[16] Arup Review of Mining Instability in Great Britain, for the Department of the Envrionment, Regional Atlas of Mining Areas (1999)

[17] Department for Environment, Food and Rural Affairs Magic website. Available at http://www.magic.gov.uk/MagicMap.aspx . (Access in April 2017)

[18] Zetica, UK Unexploded Bombs Risk Map. Available at http://www.zetica.com/productsandservices/uxbriskassessment.htm (Accessed in April 2017)

[19] Lle, Welsh Government Data Portal. Available at http://lle.gov.wale (Accessed in April 2017)

[20] Arup, A40 Llanddewi Velfrey to Penblewin Improvements, Ground Investigation Report, A40LVP-ARP-VGT-SWI-RP-C-0001 (2017)

[21] Costain, Atkins and Cresswell Associates, A40 Trunk Road Penblewin to Slebach Park Improvement Geotechnical Report, 5034100/GI/GR/RT006 (2007)

[22] Thyssen Geotechnical, A40 Robeston Wathen Bypass, Ground Investigation Factual Report Volumes 1 and 2, 7631 (1996)

[23] Highways England, Manual of Contract Documents for Highways Works, Volume 1 Specification for Highways Works, Series 600 Earthworks

Annex A

Proposed Ground Investigation (including Exploratory Hole Location Plan)

A1 Objectives and Format of Any Investigation

The objective of the proposed intrusive ground investigation is to determine the stratigraphy and obtain geotechnical, groundwater, geo-environmental and geo-chemical information for the purposes of design.

A2 Special Problems to be Investigated

There are no special problems that require to be investigated over and above those presented in the Preliminary Sources Study Report.

As identified in Section 7.1.1.1, the potential for relatively deep superficial deposits of softer composition will be investigated using boreholes positioned at appropriate locations. Whilst there is a risk of backfilled quarries, these cannot be specifically targeted and are likely to remain a risk during construction.

A3 Proposed Investigation

The recommended ground investigation for the site will comprise the following:

- five boreholes (assumed to be completed using percussive boring techniques with rotary-core follow-on) with both in situ testing and soil samples suitable for a range of geotechnical and geo-environmental laboratory testing;
- nine machine excavated trial pits with both in situ testing and soil samples suitable for laboratory testing;
- six in situ California Bearing Ratio (CBR) tests; and,
- three soakaway tests for the proposed attenuation solution.

The locations of the exploratory holes are shown on the location plan presented at the end of this Annex. The locations of the CBR tests and soakaways are not yet defined as the vertical alignment and scheme drainage solution is yet to be confirmed.

Inspection pits are required to be hand dug to a depth of 1.2m for all exploratory holes detailed above to ensure that they are clear of services. The inspection pits will be logged to provide geotechnical descriptions of the materials encountered with hand shear vane testing undertaken where the material is found to be cohesive.

All ground investigation works shall be undertaken in strict accordance with the following:

- BS 5930:2015 – Code of Practice for Ground investigations;
- BS 1377 – Methods for Test for Soils for Civil Engineering Purposes; and,
- BS EN 1997-2:2007 – Eurocode 7. Geotechnical Design. Ground Investigation and Testing.

Topographical surveys along the proposed route and particularly in the vicinity of the exploratory hole locations will be undertaken. Co-ordinates and levels of all exploratory holes will be determined.

Groundwater monitoring installations will be installed at the following locations:

- Proposed locations of cuttings, to enable equilibrium ground water levels to be determined for slope stability and slope drainage design; and,
- Main valley feature to be crossed, to inform in case material is required to be dug out and replaced.

The specific groundwater monitoring regime is to be developed once the preliminary design has been finalised.

A4 Site and Working Restrictions

At the time of writing this Preliminary Sources Study Report a site walkover had not been carried out due to land access constraints, and possible working restrictions for the proposed ground investigation have not been identified. It is envisaged, however, that the following potential restrictions may be applicable.

- Access in the vicinity of steep slopes, particularly near watercourses;
- Working immediately adjacent to watercourses;
- Potential areas of soft ground – particularly adjacent to watercourses and in low spots in the topography;
- Possible presence of heavy vegetation across proposed access, egress and working areas; and,
- Access to third party land.

Conditions should be confirmed prior to the ground investigation commencing on site, ideally through a detailed site walkover between the designer and the proposed ground investigation contractor.

A5 Specialist Consultation

In developing the project and enabling the ground investigation to progress, it is envisaged that the following consultations will be required:

- Welsh Government (as part of the HD22 certification process); and,
- Natural Resources Wales – in particular, for any work adjacent to watercourses.

An ecological and archaeological assessment of the area of proposed ground investigation is currently being completed.

A6 Programme, Cost and Contract Arrangements

It is anticipated that the Ground investigation fieldwork should take of the order of two weeks. Allowance should be made for subsequent laboratory testing and preparation of the Factual Report, which are estimated to take around an additional four weeks and two weeks respectively. Therefore, a total duration of approximately eight weeks is estimated from commencement on site through to completion of factual reporting.

Procurement of the Ground investigation will be undertaken by Carillion.

The estimated Contractor cost for the Ground investigation is of the order of £20,000 to £35,000 (excluding VAT). This figure does not include arrangements for traffic management, topographic survey, land access arrangements or supervision by an Arup geotechnical engineer.

A7 Reporting

It will be the responsibility of the ground investigation sub-contractor to prepare a Factual Report for the site. The Factual Report shall contain the following information:

- Site plan, showing the location of the exploratory hole logs;
- Exploratory hole logs (including co-ordinates and ground level);
- Core photographs;
- Trial pit photographs;
- In situ test results; and,
- Laboratory test results.

The ground investigation data will be supplied in AGS 3 Format.

The Ground Investigation Report and subsequent Geotechnical Design Reports shall be prepared by Arup once the ground investigation has been completed. These will be completed in accordance with guidance provided in HD22/08 and the requirements of BS EN 1997.

A8 Other Considerations

There is the potential for historic quarries to be located in the immediate vicinity of the proposed route. These may have been infilled with material that could pose a significant risk of contamination. If encountered, the composition of the infill will need to be determined and appropriate geo-environmental testing be undertaken.

A3

Exploratory Hole(s): 3 No. in situ soakaway tests (locations to be confirmed)
Exploratory Hole(s): 6 No. in situ CBR testing (locations to be confirmed)

Exploratory Hole(s): BH01
Depth: 8mbgl
Reasoning: High point therefore potential location of cutting. Identify nature of rock, in particular, strength and degree of fracturing to a short depth below formation level. For assessment of excavatability, design slope angles and material reuse for the Slade and Redhill Formation

Exploratory Hole(s): BH02 & BH03
Depth: 15mbgl
Reasoning: Possible low point in the topography, and therefore potential location of embankment at position where glacial till is present. To determine founding stratum where watercourse crossing/culvert may be required, and likely form of foundation. To determine parameters for stability and settlement assessment of embankment

Exploratory Hole(s): TP01
Depth: 4.5mbgl
Reasoning: To determine ground conditions local to the existing fault, which may differ significantly from elsewhere

Exploratory Hole(s): BH04
Depth: 8mbgl
Reasoning: High point therefore potential location of cutting. Identify stratigraphy that cutting may extend through, in particular, the glacial till from the surface and underlying Llandeilo Flag Formation. For assessment of excavatability, design slope angles and material reuse

Exploratory Hole(s): TP02
Depth: 4.5mbgl
Reasoning: To gain a more informed visual identification of the rock to supplement BH01, including depth and nature of upper weathered zone, and possible confirmation of bedding and dip angles for slope stability assessment

Exploratory Hole(s): TP03
Depth: 4.5mbgl
Reasoning: To provide further geotechnical information about the Slade and Redhill Formation (weathering profile)

Exploratory Hole(s): TP04
Depth: 4.5mbgl
Reasoning: To gain a more informed visual identification of the conditions to supplement BH02

Exploratory Hole(s): TP05
Depth: 4.5mbgl
Reasoning: To identify ground conditions, in particular where the Mydrim Shales Formation rock is present that has not previously been investigated

Exploratory Hole(s): TP06
Depth: 4.5mbgl
Reasoning: To determine ground conditions local to the existing fault, which may differ significantly from elsewhere

Exploratory Hole(s): BH05
Depth: 6mbgl
Reasoning: Possible low point in the topography, and therefore potential location of embankment. To determine founding stratum where watercourse crossing/culvert may be required, and likely form of foundation. To determine parameters for stability and settlement assessment of embankment

Exploratory Hole(s): TP07
Depth: 4.5mbgl
Reasoning: To gain a more informed visual identification of the rock to supplement BH04, including depth and nature of overlying superficial deposits, the upper weathered zone of rock, and possible confirmation of bedding and dip angles for slope stability assessment

Exploratory Hole(s): TP08
Depth: 4.5mbgl
Reasoning: To gain a more informed visual identification of the conditions to supplement BH05

Exploratory Hole(s): TP09
Depth: 4.5mbgl
Reasoning: To provide further geotechnical information about the Slade and Redhill Formation (weathering profile)

BH01 TP01 TP02 TP03 BH02 BH03 TP04 TP05 BH04 TP06 TP07 BH05 TP08 TP09

A40 A478 B4313 Redstone Road Stoneyford

bing

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Legend

Proposed Exploratory Holes
- BH
- TP
- Approximate Proposed Route

LiDAR Information (2004)
59-61, 61-62, 62-63, 63-65, 65-66, 66-67, 67-68, 68-70, 70-71, 71-72, 72-74, 74-75, 75-76, 76-78, 78-79, 79-80, 80-82, 82-83, 83-84, 84-86, 86-87, 87-88, 88-90, 90-91, 91-92, 92-94, 94-95, 95-96, 96-98, 98-99, 99-100, 100-102

13/06/2017 09:18:51

Issue	Date	By	Chkd	Appd
P02	2017-06-13	LU	VT	VT

Metres
0 50 100 200

ARUP

Client
Carillion / Welsh Government

Job Title
A40 Llanddewi Velfrey to Penblewin Improvements - Penblewin Junction to Redstone Road Ground Investigation

Topography (2004 Lidar)
Proposed Exploratory Hole Locations

Scale at A3
1:4,000

Job No
253875-00

Drawing Status
For Information

Drawing No
002

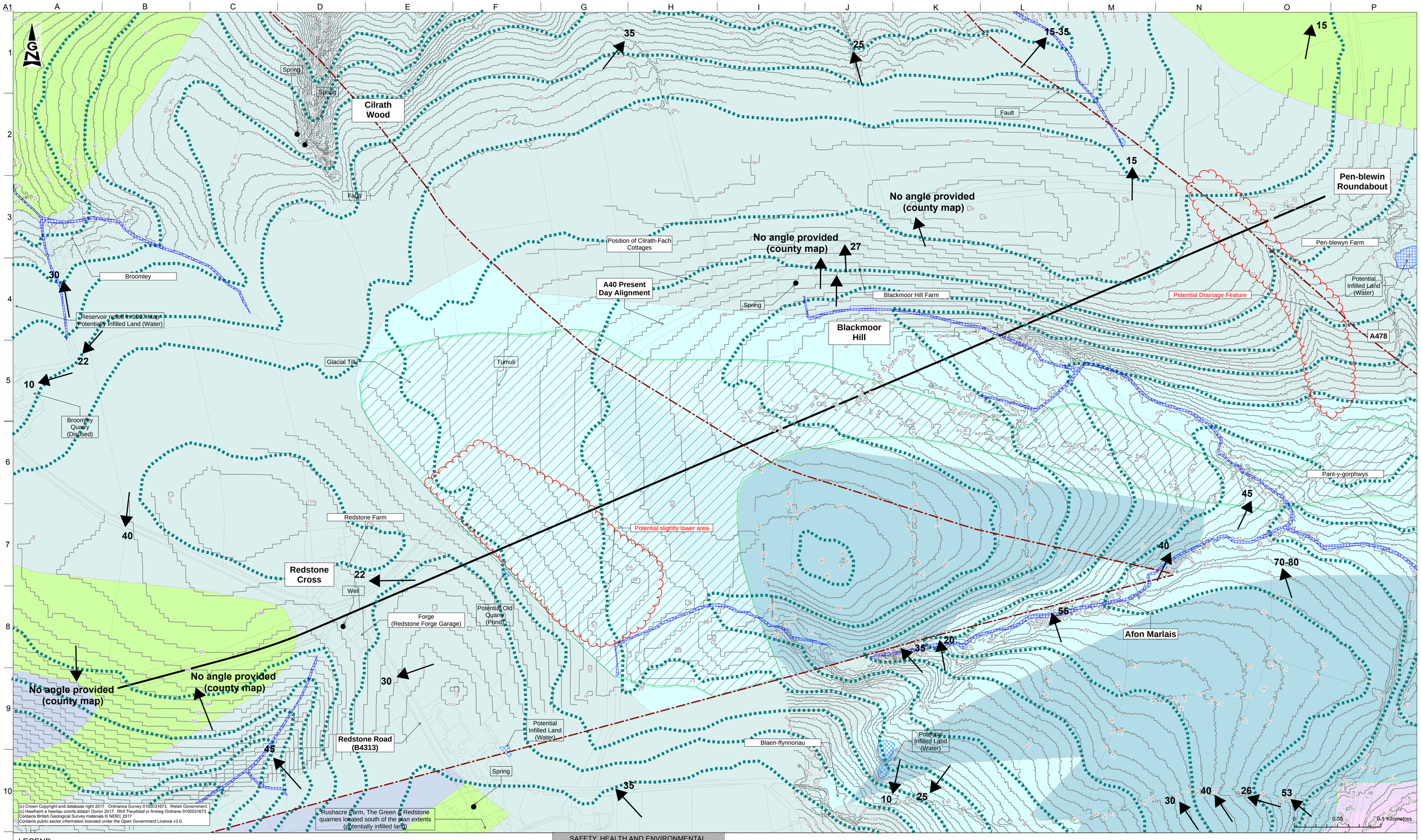
Issue
P02

\\Global\Europe\Bristol\Jobs\Standard Documents\GEO\29 Infrastructure support\A40 Extension\GIS\03 Map Documents\Master.mxd

© Arup

Appendix A

Features and Constraints Plan



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LEGEND

- PRELIMINARY HIGHWAY ALIGNMENT
- WATER FEATURE

GEOLOGY

- GLACIAL TILL
- MYDRIM SHALES FORMATION
- SLADE & REDHILL MUDSTONE FORMATION
- LLANDEILO FLAGS LIMESTONE
- GLACIOFLUVIAL DEPOSITS
- PORTFIELD & HAVERFORD MUDSTONE FORMATION - UNDIFFERNETIATED
- WATER COURSE
- FAULT
- OS CONTOUR

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P01	12/06/17	FIRST DRAFT	EB	AP	TE	--

Project Title
A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

Delivery Team
ARUP · carillion · MOTT MACDONALD · ARCADIS · RICHARDS

Drawing Title
FEATURES AND CONSTRAINTS PLAN
A40 REDSTONE CROSS IMPROVEMENTS

Suitability
S2 | SUITABLE FOR INFORMATION

Scale at A1 1:2,000

Rev	By	Chkd	Appd	Auth
P01	EB	AP	TE	--
	Date 12/06/17	Date 12/06/17	Date 12/06/17	Date --

Name
A40LVP - ARP - VGT - M02 - DR - C - 0001
Project | Originator | Volume | Location | Type | Role | Number

Appendix B

Geotechnical Risk Register

Combined Risk Register

Project Name	A40 Llanddewi Velfrey to Penblewin Improvements	**Client**	Welsh Government
Document Number	A40LVP-TK-0002	**Current Project Stage:**	KS3 Preliminary Design

Part A: Risk Identification	Risk Ref Number	Risk Location (Chainage, Structure ID, Description)	Description of risk or hazard	Date Risk Identified	Identified By (initials)	Risk Status (Rejected / Continued/ Active: Use Continued when more than one risk review has been undertaken and risk still active / Closed: Use closed when risk has been controlled by design or is passed downstream)	Discipline	Revision	Part B: Risk Assessment: Project Lifecycle Stage (during which the hazard / risk may occur)	H&S Risk (CDM Risk)	Commercial Risk	Environmental Risk	Likelihood	Severity	Risk Product (Low/Medium/High)	Relevant Documentation	Owner of Risk (Who will Manage the Risk)	Part B: Risk Elimination Action	Can the Risk be eliminated Yes/No	Mitigation or action	Part C: Residual Risk: Likelihood	Severity	Risk Product (Low/Medium/High)	Further Action Required	Continuation Risk Reference	Means of communicating the Risk (SHE boxes, drawing hazard triangle, HSP etc)
INCOMPLETE	G21	Redstone Cross Improvement	Presence of 'soft' ground along the alignment of the scheme. In particular, this is a risk in the vicinity of the various minor watercourses and low spots along the scheme, and potential for localised high degrees of weathering of the bedrock. Glacial Till is also shown to underlie part of the site. The potential impacts are: - potential for deep seated instability of embankment slopes - high magnitudes of total settlement of embankments, which may be unacceptable in terms of future performance of drainage etc. - high magnitudes of differential settlement, which may be unacceptable in terms of the finished road levels, interfaces with structures, performance of drainage, kerbs etc.	23/05/2017	VTW	ACTIVE	GEO	1	C O	H			3	5	H	PSSR (including Annex A)	Designer, Contractor		No	Site specific ground investigation to be carried out to identify general ground and groundwater conditions.	2	5	H	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G22	Redstone Cross Improvement	Faulting and unfavourable geological conditions resulting in: - possible instability of cuttings and excavations. - possible requirement for slacker/engineered cutting slopes.	23/05/2017	VTW	ACTIVE	GEO	1	C O	H	C		3	3	M	PSSR (including Annex A)	Designer		No	Site specific ground investigation to be carried out to identify general ground and groundwater conditions.	2	3	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G23	Redstone Cross Improvement	Potential for the mudstones that are present across the scheme to contain high levels of sulfates and pyritic conditions, which have the potential to: - be aggressive to concrete in contact with the ground leading to deterioration of structures over time. - deterioration/damage to the highway, structures and earthworks due to potential for expansion of soils/rock should they contain pyrite.	23/05/2017	VTW	ACTIVE	MULTI	1	O				3	4	H	PSSR (including Annex A)	Designer		Yes	Sulfate related testing to be undertaken as part of the site specific ground investigation and sulfate assessments to be been carried out in accordance with BRE Digest 1 and TRL 447.	2	4	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G24	Redstone Cross Improvement	Presence of previously unidentified made ground and contamination, and risks posed by known areas of made ground and contamination. Possible sources include, the existing roads, tracks and hardstandings; areas of past fly tipping; infilled pits and quarries; and sewage discharge points. Amongst others, possible contaminants include coal tar, metals, hydrocarbons, asbestos, high bacterial levels etc. Risks include: - potential risks to human health. For example, site operatives during construction, and future maintenance workers. - potential risks to the environment. In particular, water bodies as a consequence of potential exposure to surface water runoff and infiltration via areas of contaminated ground. - potential cost implications if materials are classified as 'unsuitable', and require disposal to an appropriately licenced facility. Possible high costs if materials are to be disposed of as non-hazardous or hazardous landfill classifications.	23/05/2017	VTW	ACTIVE	GEO	1	C		C	E	3	3	M	PSSR (including Annex A)	Designer, Contractor		No	Geo-environmental testing to be undertaken as part of the site specific ground investigation. An observational approach with a contamination watching brief shall be adopted during the ground investigation.	2	3	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G25	Redstone Cross Improvement	Site won fill material unsuitable for reuse resulting in: - possible need to dry out due to relatively high natural moisture contents, or improve (eg, lime) the material prior to or at the point of placement. - probable need to process the rock, eg through crushing and sorting, prior to placement - to achieve the required grading for use as fill. - alternative sources of fill material required. - additional disposal costs for unsuitable material. Delays during construction and cost implications for all of the above if the proportion of unsuitable material is greater than assessed.	23/05/2017	VTW	ACTIVE	GEO	1	C		C	E	3	4	H	PSSR (including Annex A)	Designer, Contractor		No	Site specific gound investigation to include a suite of suitability/acceptability tests.	2	4	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G26	Redstone Cross Improvement	Unidentified services resulting in potential damage to services presenting a H&S hazard, disruption to third parties, causing delays during construction, and possible cost implications.	23/05/2017	VTW	ACTIVE	MULTI	1	C	H	C		3	4	H	PSSR (including Annex A)	Designer, Contractor		No	Comprehensive searches through contacting all mainstream providers ahead of the site specific ground investigation and main works. Contact landowners for existing private drainage and services plans. Appropriate use of a safe system of work by the contractor, which may include cable avoidance equipment and inspection pits.	2	4	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G27	Redstone Cross Improvement	Presence of pits, quarries and unidentified pit locations potentially backfilled with animal remains. The risk is biohazard (for example: anthrax, foot and mouth) to human health and environment. See also G24	23/05/2017	VTW	ACTIVE	MULTI	1	O			E	2	3	M	PSSR (including Annex A)	Designer, Contractor		No	Desk study carried out to identify locations of known or likely potential backfilled pits. Online walkover to be undertaken which will include searching for and recording any evidence to backfilled pits. Consultation with land owner / occupier to be completed. Watching brief to be adopted during the course of the site specific ground investigation and construction works.	2	3	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G28	Redstone Cross Improvement	Dip angle of rock bedding is not suited to proposed slope angles for cuttings. There is a risk that low shear angle surfaces may exist within the rock formations, and if these are orientated so that they crop at an unfavourable angle into the cut faces, rock wedge failures are possible. Also see G22	23/05/2017	VTW	ACTIVE	GEO	1	C O	H	C		2	3	M	PSSR (including Annex A)	Designer		No	Preliminary Sources Study Report completed, which has included obtaining and interpreting field slip and county geological plans, to better inform the local solid geology. Preliminary desing likely to allow for 1 in 2 cut slope angles in rock, which should be suitably robust to ensure stability for most circumstances.	2	3	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G29	Redstone Cross Improvement	Part of the alignment overlies the Llandeilo Flags Limestone. If this formation is a massive limestone, there is the potential for cavities to be located below the proposed alignment.	23/05/2017	VTW	ACTIVE	GEO	1	C O	H	C		2	4	M	PSSR (including Annex A)	Designer		No	From the Preliminary Sources Study Report completed, the Llandeilo Flags Limestone are likely to be interbedded limestones and mudstones therefore it is unlikely that cavities are present. Ground investigation to be undertaken to confirm make-up of underlying strata.	1	4	M	Y		TBC	PSSR (including Annex A)
INCOMPLETE	G30	Redstone Cross Improvement	Potential to encounter sites of achaeological interest such as burnt mounds which have been noted in the vicinity of the scheme.	23/05/2017	VTW	ACTIVE	GEO	1	C O		C	E	3	3	M	PSSR (including Annex A)	Designer		No	Preliminary Sources Study Report completed which has noted two tumuli (CADW scheduled monuments) are present immediately north of the present day A40 alignment. Archaeological surveys to be undertaken as part of the scheme and any recommendations made shall be followed during construction.	2	3	M	Y		TBC	PSSR (including Annex A)

Risk Register Key	
Project Lifecycle Stage	
C	Construction
O	Operational
M	Maintenance
D	Demolition
CDM Risk	
H	Hazard impacts Health and Safety aspects
C	Hazard impacts Commercial aspect
E	Hazard impacts Environmental aspects
Risk Product	
L	Low
M	Medium
H	High

Welsh Government

A40 Penblewin to Redstone Cross Improvements

Revised Annex A to Preliminary Sources Study Report

A40LVP-ARP-HGT-M02-RP-C-0001

P02 | S4

03/04/19

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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3	Proposed Investigation	2
4	Site and Working Restrictions	3
5	Specialist Consultation	4
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7	Reporting	5
8	Other Considerations	6
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1 Objectives and Format of Any Investigation

1.1.1 A Preliminary Sources Study Report (PSSR) was completed in 2017 for the original scheme extent from the Penblewin Roundabout to Redstone Cross; A40LVP-ARP-HGT-J01-RP-C-0001, P03. Since completion of the PSSR the proposed scheme has been extended a further 600m to the west and will now extend from the existing Penblewin Roundabout and tie back into the existing A40 approximately 600m to the west of the Redstone Cross Junction.

1.1.2 This revised Annex A supersedes the version appended to the PSSR and contains the proposed scope of works for the revised scheme.

1.1.3 The objective of the proposed intrusive ground investigation is to determine the ground conditions and obtain geotechnical, groundwater, geo-environmental and geo-chemical information for the purposes of design, to establish a baseline for the Environmental Statement and to reduce uncertainty associated with the ground and proposed form of construction ahead of tender.

1.1.4 It should be acknowledged that the full scope presented in this document may not be achievable at this stage should there be particular environmental, landowner and practical constraints for its completion. As the design is under development, the potential need for supplementary ground investigation at a later date cannot be ruled out.

2 Special Problems to be Investigated

2.1.1 In addition to providing information on the site-wide ground and groundwater conditions, the PSSR has identified several special features across the site for investigation. These are as follows:

a) Pond (approximately 170m to the east of the Redstone Cross Junction), this feature has the potential to be a historical infilled quarry;

b) Redstone Forge garage (located at the Redstone Cross Junction), this could be a potential source of contamination.

2.1.2 There is also potential for relatively deep, soft superficial deposits, particularly in proximity to the watercourses, which are targeted for investigation.

2.1.3 There is also a risk of unidentified backfilled quarries and pits which may remain a risk during construction.

3 Proposed Investigation

3.1.1 The recommended ground investigation for the site is described below based on the current scheme proposals discussed in Section 1. This will form the main ground investigation for the design and inform the baseline and associated assessments for the Environmental Statement. The following approximate scope is recommended:

a) Three boreholes along the proposed embankment in the south west of the scheme, to identify the stratigraphy, obtain insitu test results and obtain soil samples for strength and compressibility testing for assessment of embankment stability and settlement. These will be supplemented by four trial pits to provide information on the potential variation in ground conditions along the length of embankment.

b) Six boreholes along the length of the main embankment proposed in the central area of the scheme, spaced at regular spacings to identify the stratigraphy, obtain insitu test results and obtain soil samples for strength and compressibility testing for assessment of embankment stability and settlement. These will be supplemented by six trial pits to provide information on the potential variation in ground conditions along the length of embankment, and fifteen dynamic sample holes at the two localised low spots to confirm the approximate vertical and lateral extent of any soft ground that may be present.

c) Two boreholes along the alignment of the proposed cutting in the north-east of the scheme, to identify the stratigraphy, to obtain samples for strength testing to support slope stability assessment, and to identify equilibrium groundwater levels for slope drainage design. These will be supplemented by five trial pits, to provide information on ground conditions at regular spacings along the cutting, and to obtain soil samples suitable for laboratory contamination and geotechnical testing, including testing to assess earthworks suitability from proposed cuttings. The contamination test results will inform the contaminated land baseline for the Environmental Statement and the need for any specific design or mitigation measures.

d) Two soakaway tests to be carried out in trial pits positioned at the locations of the proposed attenuation ponds. These will be supplemented by a shallow borehole at each attenuation pond location, in order to identify long term groundwater levels and to obtain groundwater samples for groundwater quality testing to inform the groundwater baseline for the Environmental Statement.

e) In-situ California Bearing Ratio (CBR) tests at trial pit locations where the highway is to be formed approximately at-grade.

f) Installation of groundwater level and quality monitoring instrumentation in selected boreholes, in particular at the locations of planned and potential drainage discharges, and at the locations of the significant cuttings. The information obtained will inform the groundwater baseline for the Environmental Statement.

g) All boreholes are planned to be completed using percussive boring techniques with rotary-cored follow-on, with in situ testing and soil samples suitable for a range of geotechnical and geo-environmental laboratory testing.

3.1.2 The locations of the exploratory holes are shown on the location plan attached to this Annex. The locations of the CBR tests are to be confirmed as the vertical alignment and scheme drainage solution is under development.

3.1.3 All ground investigation works are planned to be undertaken in accordance with the project ground investigation specification and the following:

a) BS 5930:2015 – Code of Practice for Ground investigations;

b) BS 1377 – Methods for Test for Soils for Civil Engineering Purposes; and,

c) BS EN 1997-2:2007 – Eurocode 7. Geotechnical Design. Ground Investigation and Testing.

3.1.4 Samples from watercourses located adjacent to the site, and in particular, where drainage discharges may be proposed will be obtained and tested as part of the investigations to inform the surface water quality baseline for the Environmental Statement.

3.1.5 A factual report will be required by the specialist contractor for the ground investigation and digital data shall be provided in AGS4 format.

4 Site and Working Restrictions

4.1.1 At the time of writing a site walkover had not been carried out to target potential access and egress constraints to the ground investigation. As such there are possible working restrictions for the proposed ground investigation that have not yet been identified.

4.1.2 It is envisaged that the following potential restrictions may be applicable.

a) The site area is recorded to have potential archaeological constraints, it is anticipated that an archaeological watching brief will be required during the trial pitting works.
b) The site area is known to contain several ecological constraints. In particular, there is potential for dormice and badgers to be present. An ecological survey will be required ahead of any intrusive works.
c) Possible presence of heavy vegetation across proposed access, egress and working areas.
d) Access to steep slopes, particularly near watercourses.
e) Working immediately adjacent to watercourses.
f) Potential areas of soft ground – particularly adjacent to watercourses and in low spots in the topography.
g) Access to third party land.

4.1.3 Site conditions will be reviewed with the specialist contractor and specific exploratory hole locations confirmed prior to the ground investigation commencing on site.

4.1.4 If vegetation clearance and intrusive works are required within proximity of the watercourses, the appropriate permits will need to be obtained from the statutory bodies in advance of the works.

4.1.5 Buried services searches will also be undertaken in advance of commencement of the works on site.

5 Specialist Consultation

5.1.1 In developing the project and enabling the ground investigation to progress, it is envisaged that the following consultations will be required:

a) Welsh Government (as part of the HD22 certification process); and,
b) Natural Resources Wales – in particular, for any work adjacent to watercourses and for vegetation clearance.

5.1.2 An ecological assessment for the area of proposed ground investigation is proposed in advance of the ground investigation works.

6 Programme, Cost and Contract Arrangements

6.1.1 It is anticipated that the Ground investigation fieldwork should take approximately three weeks, although this will be dependent on the type and number of rigs selected by the specialist contractor. Allowance should be made for subsequent laboratory testing and preparation of the Factual Report, which are estimated to take a combined total of six weeks following completion of the fieldwork. Therefore, a total duration of approximately nine weeks is estimated from commencement on site through to completion of factual reporting.

6.1.2 It is proposed that the works will be carried out under the Thomas Telford Specification for Ground Investigation (2012).

6.1.3 Arup will manage the procurement, contract management and supervision of the works on behalf of Welsh Government, with Welsh Government acting as Employer for payment purposes. It is proposed that the specialist contractor for the works will act as Principal Contractor.

6.1.4 The estimated contractor cost for the ground investigation is of the order of £40,000 to £60,000 (excluding VAT). This figure does not include arrangements for traffic management, topographic survey, land access arrangements or technical and site-based support by Arup.

7 Reporting

7.1.1 The specialist ground investigation contractor will prepare a Factual Report for the site. The Factual Report shall be in line with the project specific specification and contain the following information:

a) Summary of the works undertaken.
b) Site plan, showing the location of the exploratory hole logs.
c) Exploratory hole logs (including co-ordinates and ground level).
d) Core photographs.
e) Trial pit photographs.
f) In situ test results.
g) Laboratory test results.

7.1.2 The ground investigation data will be supplied in AGS4 format, in line with the requirements of the project specific specification.

7.1.3 The Ground Investigation Report and subsequent Preliminary Geotechnical Design Report shall be prepared by Arup after the ground investigation has been completed. These will be completed in accordance with HD22/08.

8 Other Considerations

8.1.1 There is the potential for historic quarries in the immediate vicinity of the proposed route. These may have been infilled with material that could pose a risk of contamination. If encountered, the composition of the infill will need to be determined and appropriate geo-environmental testing be undertaken.

Appendix A

GI Location Plan 01
A40LVP-ARP-VGT-M02-DR-C-0003 – Revision P02

A3

LEGEND

PROPOSED GI

- BH
- DS
- SW
- TP

EXISTING GI

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction	None
Maintenance / Cleaning	None
Use	None
Decommissioning / Demolition	None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	03/04/19	ISSUE FOR TENDER	AT	MC	TE	GD

Project Title

A40 LLANDDEWI VELFREY TO PENBLEWIN IMPROVEMENTS

Client

Llywodraeth Cymru
Welsh Government

Delivery Team

ARCADIS · MOTT MACDONALD · ARUP · RICHARDS

Drawing Title

PROPOSED GROUND INVESTIGATION PLAN
SHEET 1 OF 3

Suitability

S4 | SHARED FOR STAGE APPROVAL

Scale at A3

1:6,000

Rev	By	Chkd	Appd	Auth
P02	AT	MC	TE	GD
	Date	Date	Date	Date
	03/04/19	15/03/19	15/03/19	15/03/19

Name

Project	Originator	Volume	Location	Type	Role	Number
A40LVP	ARP	VGT	M02	DR	C	0003

A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

GROUND INVESTIGATION

Factual Report

Report No. Q0083/FR December 2019

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Disclaimer: Quantum Geotechnic Limited has prepared this report in accordance with the instructions of the above named Client for their sole and specific use. Any third parties who may use the information contained herein do so at their own risk.

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0. FOREWORD

The following Conditions and Notes on Site Investigation Procedures should be read in conjunction with this report.

0.1. General

Recommendations made and opinions expressed in the report are based on the strata observed in the excavations, together with the results of site and laboratory tests. No responsibility can be held for conditions which have not been revealed by the Exploratory Holes or which occur between Exploratory Holes. Whilst the report may suggest the likely configuration of strata, both between Exploratory Holes and below the maximum depth of investigation, this is only indicative and liability cannot be accepted for its accuracy.

Unless specifically stated, no account has been taken of possible subsidence due to mineral extraction below or close to the site.

0.2. Investigation Procedures

Cable Percussive, Dynamic Sampling and Rotary Cored borehole drilling techniques for ground investigation have been employed within the project. All Exploratory Hole operations, sampling and logging of soils, rocks and in-situ testing complies with the recommendations of the British Code of Practice BS 5930:2015, 'Site Investigations', British Code of Practice BS 10175: 2011 + A1:2013, 'Investigation of Potentially Contaminated Sites' and BS 1377: 1990, 'Methods of Test for Soils for Engineering Purposes'.

0.3. Routine Sampling

Representative bulk, undisturbed, disturbed and environmental samples of the different strata are taken following completion of logging. These samples are sealed and labelled in clear plastic bags and 2kg plastic tubs. Soil samples obtained for environmental testing are sampled and sealed in borosilicate amber jars or in specialist vessels where required. All samples are returned from site to QGL's laboratory for controlled storage within 24 hours of sampling to await test scheduling /requirements.

0.4. In-Situ Testing

In-situ testing comprised:

- Standard Penetration Tests (SPTs) in Boreholes
- Soakaway Testing
- California Bearing Ratio (CBR)

0.5. Groundwater

Where possible, the depth of entry of any influx of groundwater is recorded during the course of excavation or boring operations. The rate of inflow into the excavation or borehole is monitored during the course of the excavation or during boring procedures. Upon encountering any water strikes, work is temporarily halted and the water levels monitored for a standard twenty minute period recording the change in water level at the end of the twenty minutes.

Groundwater conditions observed in the excavations are those appertaining to the period of investigation. It should be noted, however, that groundwater levels are subject to diurnal, seasonal and climatic variations and can also be affected by drainage conditions or other causes.

0.6. Retention of Samples

After satisfactory completion of all the scheduled laboratory tests on any sample, the remaining material is discarded. Further to notifying the Engineer/ Client with one week's notice all soil and/or rock samples will be discarded 28 days after submission of the approved final report with the exception of the core. Long term core retention is included in the contract.

1. INTRODUCTION

1.1. General

Upon the instructions of the Welsh Government Ministers (WGM), and the Engineer Arup, Quantum Geotechnical Limited (QGL) was commissioned to undertake a ground investigation at the A40 Penblewin to Redstone Cross.

The site was situated along the route of a proposed new highway alignment between Penblewin Roundabout and 500m west of Redstone Cross including access road. The investigation was located to the south of the existing A40 in the arable.

The instruction for the works was received from WGM Construction dated 23rd August 2019 (Ref 20-28-68-48) for works in accordance with Arup produced specification (Ref A40LVP-ARP-HGT-M02-RP-C-003). QGL were the Principal Contractor for the works. The works were commissioned in order to establish general ground conditions and strata sequences across the site, develop material properties for the future designs, produce a geotechnical data relating to the proposed earthworks and to take contamination samples across the site

This report presents a factual account of the fieldwork carried out, includes descriptions of the strata encountered, available groundwater observations, details of in-situ testing undertaken, and provides results of subsequent laboratory testing of samples obtained from the investigation.

General notes on the techniques employed by QGL are described in the Foreword together with the limitations inherent in carrying out site investigation work.

The approximate site OS Grid Reference is SN 11221 16350.

The Project Manager and Investigation Supervisor for the Contract and during the works was Arup.

A Site Location Plan is presented as Figure 1 in Appendix I.

Other available sources of information that have been consulted in the preparation of this Factual Report include the published geological maps for the area and online databases.

General notes on the techniques employed by QGL are described in the Foreword together with the limitations inherent in carrying out site investigation work.

1.2. Purpose of Ground Investigation

The purpose of the ground investigation is to provide information on the prevailing ground conditions to allow design of the proposed new alignment of the A40 between the Pemblewin roundabout and 0.5km west of Redstone Cross. This included geotechnical and geo-environmental sampling and investigations together with monitoring of groundwaters and surface waters. Samples were gained for laboratory testing. In-situ testing was also undertaken as part of these works.

1.3. Scope of Work

The scope of work was designed by Project Manager / Investigation Supervisor and comprised the following;

- 8 No. boreholes drilled using cable percussion methods with rotary percussive follow-on.
- 1 cable percussion borehole
- 8 rotary open hole followed by rotary core techniques borehole
- In-situ SPT tests in the cable percussion and rotary boreholes.
- 17 No. trial pits (mechanically or hand excavated).
- 7 No. California bearing ratio tests.
- 4 No. Soakaway tests
- Geotechnical and Geo-environmental Laboratory Testing.
- Provide a factual report detailing the investigation.

General notes on the techniques employed by Quantum Geotechnical are described in the Foreword together with the limitations inherent in carrying out ground investigation work.

The exploratory hole locations were scoped and positioned by the Arup and marked out using GPS in liaison with the engineer. The locations of each exploratory hole are presented on the associated drawings in Appendix I.

2. SITE DETAIL

2.1. Site Description

The site is situated east of the town of Llandewy Velfrey and is approximately 18km east of Haverfordwest. The site is located along the route of a proposed new road situated to the south the existing A40. The site is approximately 2km long and crosses the B4313. The east of the site is defined by the Penblewin roundabout, the route heads southwest from that point increasing separating from the existing A40. The route continues southwest roughly paralleling the A40 crossing the B4313 before re-joining the A40 0.5km west of the Redstone Cross Junction.

The site comprises arable fields and woodland and is generally gently undulating topography. In the east some 300m southwest of the Penblewin Roundabout there is a steep grassy slope down to the west. The majority of the site is grass land fields with sections of woodland between. During the investigation initially the fields were dry and easily passable, however, as the weather deteriorated during the works sections of the site quickly became water logged.

There are two unnamed streams that cross the site; one in the east running flowing west to east approximately 300m southwest of the Penblewin Roundabout, the second running northeast to southwest in the west of the site approximately 100m west of Redstone Cross.

2.2. Statutory Service Information

All service information was held by the client with the relevant plans and information made available to QGL prior to commencement of the intrusive works.

A permit to excavate was issued by QGL for the exploratory holes. Standard QGL procedures for breaking ground were followed and all areas were scanned using a cable avoidance tool. A hand dug trial pit was excavated to 1.2m prior to commencement of drilling. All hand excavation was undertaken using insulated digging tools.

2.3. Published Geology

Details of the geology of the site are provided by British Geological Survey (BGS) Sheet 228 ‘Haverfordwest’, Solid and Drift edition at 1:50,000 scale, and BGS’s online tool Geology of Britain Viewer.

2.3.1. Made Ground Deposits

No Made Ground is indicated beneath or in the vicinity of the site. It is likely that locally some areas of Made Ground may be resent associated with localised developments or associated with the previous highway works.

2.3.2. Superficial Deposits

Maps indicate the site has little in the way of superficial deposits beneath the site. The only superficial deposits noted are an area of Boulder Clay indicated between 200m east of Redstone Cross to 500m west of Penblewin roundabout which is associated with the change of topography at this location.

2.3.3. Bedrock

Solid geology beneath the site comprised the Upper Valentian Series (specifically the Haverford west beds) of Silurian Age in the west with the middle and east portions of the site underlain by the Bala Series (specifically the Slade and Redstone beds, Bala Limestones and Dicranograptus beds) of Ordovician Age. The soil geology comprises mainly shales and mudstones to grits and limestones possible. Generally, the beds are indicated to dip between 45 and 15 degrees to the northeast though locally this does vary with dips to the north east and south recorded to the north and south of the site respectively.

The site is underlain or potentially by 3 conjectural unnamed faults. The first fault is indicated to run roughly east to west paralleling the site to the south. The second crosses the site in a north west to south east direction approximately halfway between Redstone Cross and Penblewin roundabout. The third runs parallel to the second fault approximately 100m west of Penblewin roundabout. No trust direction is given for any of these faults.

3. FIELDWORK

3.1. General

The fieldwork was carried out between the 3rd September and 4th December 2019. Full-time on-site supervision and attendance by an Engineering Geologist from QGL was undertaken on all aspects of the site works and subsequent reinstatement works of all exploratory hole locations.

All works were conducted within safe working practices set out by QGL's Risk Assessed Method Statement including CAT scanning and service inspection hand excavated pits of all exploratory hole locations. All inductions and daily site briefings were carried out by QGL's Engineering Geologist with continued liaison with the Client's Investigation Supervisor. No incidents or near misses were recorded during the fieldworks, with the works being incident free.

Access to locations was not always possible due to land owner issues. As such the programme of works was altered repeatedly to accommodate the changing land owner requirements and availability of locations. It was not possible to access two locations, TP16 and TP17, as the land owner refused access to this area.

In addition, the wet ground conditions in the area of BH08 and BH09 deteriorated dramatically due to heavy rain fall in the latter stages of the works and this prevented safe access to the Dynamic sampler locations in this area. Several attempts were made using tracked machines and hand held equipment but access could not safely be gained.

3.2. Exploratory Hole Locations

The exploratory hole locations were set out by QGL in agreement with the Investigation Supervisor on during the fieldwork.

On completion of the ground investigation exploratory hole positions were surveyed to ordnance datum (accurate to 0.005m horizontal and 0.01m vertical).

An Exploratory Hole Location Plans are presented as Figure 3a to 3d in Appendix I, and exploratory hole coordinates and levels are presented on the engineer's log sheets in the corresponding Appendices. Table 1 presents the National Grid Co-Ordinates and Ordnance Datum for the exploratory holes:

Table 1: *Exploratory Hole Co-Ordinates & Levels*

Exploratory Hole ID	Easting	Northing	Height (mAOD)	Location on Site
RCEBH01	210521.43	216044.73	87.97	RCE
RCEBH02	210770.6	216073.89	93.6	RCE
RCEBH03	210878.08	216084.14	100.06	RCE
RCEBH04	211012.7	216150.36	100.61	RCE
RCEBH5CP	211168.1	216251.78	89.74	RCE
RCEBH05ROT	211173.9	216251.2	89.73	RCE
RCEBH06	211215.85	216285.68	88.88	RCE
RCEBH07	211309.31	216358.26	86.49	RCE
RCEBH08	211492.09	216439.53	80.39	RCE
RCEBH09	211539.69	216467.1	78.1	RCE
RCEBH10	211730.96	216505.6	90.96	RCE
RCEBH11	211811.51	216529.07	93.29	RCE
RCEBH12	210931.84	216077.95	103.31	RCE
RCEBH13	210909.11	216110.98	101.9	RCE
RCEBH14	210958.32	216115.39	103.66	RCE
RCEBH15	210746.24	216054.88	93.55	RCE
RCEBH16	210813.56	216012.25	91.84	RCE
RCEDS01	210801.71	216089.72	91.2	RCE
RCEDS02	210776.45	216071.24	92.19	RCE
RCEDS03	210736.94	216028.29	90.03	RCE
RCEDS04	210779.84	215999.62	85.02	RCE
RCEDS05	210823.32	216079.51	92.56	RCE
RCEDS06a	211179.89	216250.54	89.61	RCE
RCEDS06b	211185.24	216238.51	89.32	RCE
RCEDS07	211204.3	216226.88	88.95	RCE
RCEDS08	211116.41	216250.79	90.98	RCE
RCEDS09	211145.34	216249.59	90.3	RCE
RCEDS10	211207.55	216213.7	88.68	RCE
RCESA12	211585.06	216434.87	78.743	RCE
RCETP01	210357.65	216009.71	75.38	RCE
RCETP02	210573.89	216048.57	91.75	RCE
RCETP03	210653.64	216052.76	94.42	RCE
RCETP04	210719.07	216054.98	94.73	RCE
RCETP05	210893.71	216082.71	101.33	RCE
RCETP06	210992.55	216122.25	102.9	RCE
RCETP07	211051.34	216163.7	96.12	RCE
RCETP08	211178.32	216263.01	89.57	RCE
RCETP09	211274.54	216345.76	87.17	RCE
RCETP10	211364.72	216402.22	84.56	RCE
RCETP11	211503.1	216458.26	79.67	RCE
RCETP12	211529.82	216432.08	79.43	RCE

RCETP13	211689.79	216487.2	84.02	RCE
RCETP14	211762.41	216513.46	92.53	RCE
RCETP15	211852.9	216548.15	93.11	RCE
RCETP18	210931.73	216101.61	102.95	RCE
RCETP19	210893.2	216045.17	102.14	RCE
RCE-AR01	210967.28	216114.14	103.66	Archaeology Trench only
RCE-AR01	210977.25	216120.64	103.42	Archaeology Trench only
RCE-AR02	210949.89	216102.79	103.74	Archaeology Trench only
RCE-AR02	210962.8	216111.1	103.74	Archaeology Trench only

3.3. Boreholes

Cable tool percussive techniques were used to sink the 15 boreholes through the overlying superficial deposits. With the exception of BH01, BH02, BH10, BH11, BH15 and BH16 150mm casing was used. Boreholes BH01, BH02, BH10, BH11, BH15 and BH16 encountered bedrock in the hand excavated pits so cable percussion drilling was not undertaken and rotary coring commenced form the base of the pit. UT100 samples were taken when possible. Representative bulk and disturbed samples were recorded from each borehole throughout the boring works for geotechnical characterisation of the underlying ground conditions.

Commachio MC305 and MC450 track-mounted rotary drilling rigs were used to progress the boreholes through the underlying solid geology to maximum depths of 16.0mbgl (below ground level).

Rotary coring was used to recover rock sample of a minimum 76mm diameter from the boreholes by collecting the rock in a 1.5m length core barrel ended by a toothed ‘core bit’. Rigid plastic liner (coreliner) was employed where possible to reduce disturbance of the core both during drilling and subsequent handling, giving a triple lined approach to coring. An air mist flush was used to clear the hole of returns and debris. Due to localised rock fracturing and weathering core recovery was occasionally poor. To attempt the reduce core los the drilling was reduced to 1.0 and occasional 0.5m runs. SPT(C)s were required in the rotary boreholes initially at 1.5m intervals which was changed to 3.0m intervals, instructed by Arup, to reduce core loss through fracturing of the rock.

A summary of the boreholes is provided in Table 2.

Table 2: *Borehole summary detail*

Exploratory Hole ID	Termination Depth mbgl	Drill Methods Employed
RCE-BH01	10	Rotary from G.L to 10.0mbgl
RCE-BH02	12.5	Rotary from GL to 10.0mbgl
RCE-BH03	12	Rotary from GL to 12.0mbgl
RCE-BH04	14	Cable Percussive from GL to 1.5mbgl. Rotary from 1.5 to 14.0mbgl
RCE-BH05CP	5.5	Cable Percussion GL to 5.5mbgl
RCE-BH05ROT	14	Rotary from GL to 14.0mbgl
RCE-BH06	14	Cable Percussive from GL to 6.5mbgl. Rotary from 6.5 to 14.0mbgl
RCE-BH07	14	Cable Percussive from GL to 9.5mbgl. Rotary from 9.5 to 14.0mbgl
RCE-BH08	15	Cable Percussive from GL to 4.5mbgl. Rotary from 4.5 to 15.0mbgl
RCE-BH09	14	Cable Percussive from GL to 2.5mbgl. Rotary from 2.5 to 14.0mbgl
RCE-BH10	16	Rotary from GL to 16.0mbgl
RCE-BH11	16	Rotary from GL to 16.0mbgl
RCE-BH12	14	Cable Percussive from GL to 3.0mbgl. Rotary from 3.0 to 14.0mbgl
RCE-BH13	14	Cable Percussive from GL to 1.0mbgl. Rotary from 1.0 to 14.0mbgl
RCE-BH14	14	Cable Percussive from GL to 2.5mbgl. Rotary from 2.5 to 14.0mbgl
RCE-BH15	14.3	Rotary from GL to 14.3mbgl
RCE-BH16	14	Rotary from GL to 14.0mbgl

The recovered sample liners from rotary cored sections of the boreholes were split, photographed and logged in accordance with BS5930: 2015; BS EN ISO 14688-1:2002; BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003, by a QGL Engineering Geologist. All retrieved core is stored in wooden lockable boxes and was logged and photographed on site prior to being transported back to QGL premises for storage. The soil samples and undisturbed samples obtained from the cable percussive drilled sections were also logged by QGL Engineering Geologist.

Chiselling details could not be clearly displayed on the logs. Below are the details of the chiselling undertaken in the cable percussion boreholes.

Table 3: *Chiselling summary*

Exploratory Hole ID	Chiselling		
	Top Depth (m)	Bottom Depth (m)	Time (Hr)
RCE-BH04	0.7	1.2	1:00
	1.3	1.5	1:00
RCE-BH05CP	5.4	5.5	1:00
RCE-BH06	3.7	4.0	1:00
	4.7	4.9	1:00
	5.7	6.1	1:00
	6.2	6.5	1:00
RCE-BH07	3.9	4.0	0:30
	5.2	5.6	1:00
	5.9	6.2	1:00
	6.5	6.9	1:00
	7.2	7.6	1:00
	8.8	9.2	1:00
RCE-BH08	2.7	3.1	1:00
	4.2	4.5	1:00
RCE-BH09	1.8	2.1	1:00
	2.8	3.0	1:00
RCE-BH12	2.4	2.7	1:00
	2.7	3.0	1:00
RCE-BH13	0.8	1.0	1:00
RCE-BH14	1.4	1.7	1:00
	1.7	2.0	1:00

Copies of the engineering geologist's composite borehole logs are presented in Appendix II.

3.4. In-Situ Testing

3.4.1. Standard Penetration Testing

Standard penetration tests (SPTs) were undertaken in all boreholes through the superficial deposits and weak bedrock at intervals detailed within the Specification.

This dynamic in-situ test measures the density of soil or rock and is described in BS1377:1990 (part 9), partially superseded by BS EN ISO 22476-3 (2005). Within fine grained or cohesive soils, the test incorporates a small diameter tube (650mm length, 50mm external diameter and 35mm internal diameter) with a cutting shoe known as the 'split barrel sampler'. The sampler is forced into the soil dynamically using blows from a 63.5kg hammer dropped through 760mm. The sampler is initially advanced 150mm into the soil with seating blows, then the

number of blows required to advance the sampler each 75mm increment up to a depth of 300mm is recorded. This cumulative total number of blows over the 300mm test is referred to as the "N" value. For coarse gravels and bedrock, the split barrel is replaced by a 60° cone.

SPT results can be found on the corresponding borehole logs in Appendix II.

3.5. Groundwater Standpipe Installations

Standpipes comprising 50mm (internal) diameter standpipes were installed in all boreholes for the purposes of groundwater monitoring and sampling.

Monitoring standpipes consist of plastic pipework set in filter aggregate (pea gravel) forming a well. The filter is sealed at one or both ends by use of bentonite pellets which 'go off' and become watertight. Parts of the pipe itself are slotted, allowing the infiltration of groundwater which can then be accessed through the pipe from ground level. Slotted sections are covered by 'geo-sock' to reduce the intrusion of silt into the standpipes and the range of depths at which the groundwater is intercepted is known as the 'response zone'.

Standpipes were installed using 3m lengths of pipework (threaded at either end) fitted together and lowered into the borehole. The boreholes were then filled with either pea gravel or bentonite pellets (depending on which zone or level) and cemented in place with a raised lockable cover.

Each standpipe installation was designed by the Investigation Supervisor and instructed on site, subsequent to the completion of each borehole. All standpipe installations were sealed above the response zone by bentonite pellets to just below surface. All boreholes were finished with raised covers, 300mm of concrete and a fence.

Due to land owner constraints the final round of water sampling could not be completed in one visit and a subsequent additional visit had to be scheduled for the 4th December 2019. The results of this testing will be issued as an addendum to this report.

A summary of the pipe installation details is presented in Table 3.

Table 4: *Borehole Installation Details*

Exploratory Hole ID	Installation Pipe ID	Standpipe Diameter (Internal mm)	Response Zone (mbgl)		Total Standpipe Length (m)
			Top	Bottom	
RCE-BH01	1	50	9.0	10.0	10.0
RCE-BH02	1	50	9.5	10.5	10.5
RCE-BH03	1	50	8.0	10.0	10.0
RCE-BH04	1	50	6.0	7.5	7.5
RCE-BH05CP	1	50	3.5	4.5	4.5
RCE-BH05ROT	1	50	none	none	none
RCE-BH06	1	50	4.5	5.5	5.5
RCE-BH07	1	50	4.0	5.0	5.0
RCE-BH08	1	50	9.0	10.5	10.5
RCE-BH09	1	50	2.2	3.2	3.2
RCE-BH10	1	50	14.0	16.0	16.0
RCE-BH11	1	50	5.0	6.5	6.5
RCE-BH12	1	50	7.5	8.5	8.5
RCE-BH13	1	50	8.0	9.5	9.5
RCE-BH14	1	50	7.0	8.5	8.5
RCE-BH15	1	50	6.0	7.5	7.5
RCE-BH16	1	50	7.5	9.5	9.5

3.6. Groundwater Post-Fieldwork Monitoring

The borehole standpipe installations were monitored for groundwater levels during and following the completion of the siteworks. The results of which are recorded in Appendix V. Post-fieldwork monitoring visits were undertaken on a 10-day cycle. The final visit was taken on the 25th November and with therefore these results shall be issued as part of the final report to the Investigation Supervisor and Client.

3.7. Soil Sampling

Sampling of soils and waters were undertaken as instructed by the Client in accordance with the specification, BS 5930:2015 and BS EN ISO 22475-1:2006. Bulk, disturbed and undisturbed samples were taken where required within the superficial deposits for strata identification and laboratory testing purposes.

Sample type depth are recorded on the corresponding exploratory hole logs found within Appendices II, III and IV.

Geotechnical samples were returned from site to QGL's laboratory for controlled storage to await test

scheduling/requirements. For specific details of laboratory testing see Section 4.

3.8. Water Sampling

Water samples were taken it 3 post fieldwork visits on the 5th, 14th and 25th November 2019. All borehole installations were sampled including 4 surface water sample locations (details below). Water samples were collected using individual bailers for each location, the required sampling jars as specified by the laboratory and dispatched to the laboratory in the same day in temperature-controlled boxes.

Table 5: *Surface water sampling locations*

Exploratory Hole ID	Easting	Northing	Height (mAOD)	Location on Site
RCE-SW01	210386.51	215821.07	55.66	RCE
RCE-SW02	210802.71	216081.47	88.14	RCE
RCE-SW03	211572.21	216412.96	78.16	RCE
RCE-SW04	211569.54	216491.16	75.06	RCE

The surface water locations are presented on the Site Overlay Plan in Appendix I. Results of the water sampling are presented in Appendix IX.

4. LABORATORY TESTING

The laboratory testing was scheduled by the Client and comprised a number of geotechnical and geo-environmental tests on selected soil samples recovered from the investigation.

4.1. Geotechnical Laboratory Testing

Geotechnical tests undertaken on selected soil and rock samples are detailed in Table 4. All the geotechnical soil testing work was carried out in accordance with the procedures stipulated in the various sections of BS 1377:1990 "Methods of test for soils for civil engineering purposes" and to UKAS accreditation where applicable.

Table 6: *Geotechnical Laboratory Tests (Soil & Rock)*

Test	Number of Tests
Moisture Content	118
4 Point Liquid & Plastic Limit	118
PSD Wet Sieve method	69
PSD: Sedimentation by pipette carried out separately	42
Organic Matter Content-dichromate method	12
Loss on Ignition	13
BRE Suite B Greenfield Site (pyrite present) includes pH, water & acid soluble sulphate and total sulphur	37
Dry Den/MC (2.5kg Rammer Method 1 Litre Mould)	5
Dry Den/MC (2.5kg Rammer Method CBR Mould)	4
MCV/Moisture Content Relation	5
One-dimensional Consolidation 75mm or 50mm diameter specimens (5 days)	7
Quick Undrained Triaxial Compression test - single specimen at one confining pressure (100mm or 38mm diameter)	4
Immediate Shear Strength - set of 3 60 x 60 mm Shear Box Specimens by Direct Shearing	3
Determination of Point Load Value Axial or Diametrical including WC	34

A full set of geotechnical laboratory test certificates are provided within Appendix VII. Some testing could not be completed in time for this report and will be issued as an addendum letter.

4.2. Geo-Environmental Laboratory Testing

Geo-environmental testing was carried out on selected soil samples gained from the ground investigation. These included a combination of Suites as specified within the Contract Specification.

Table 7: *Geo-environmental Laboratory Tests (Soil & Water)*

Test Suites	Number of Tests
Soil	
Suite E1 –Soil samples General	22
Suite E2 –Soil samples Asbestos	0
Suite E3 –Soil samples TPHCWG and BTEX	11
Suite E4 –Soil samples PAH	21
Suite E5 –Soil samples VOC and SVOC	0
Suite E6 –Soil samples PCB	0
Suite E7 –Soil samples Hydrocarbon fuel identification	11
Suite E8 –Soil samples Hexavalent chromium	4
Suite E9 - Soil samples - Other tests	0
Suite H –Waste acceptance Total Soils	4
Suite I – Leachability	4
Suite J1	6
Water	
Suite F1 –Water samples General	60
Suite F2 –Water samples Speciated TPH and BTEX	22
Suite F3 –Water samples PAH	60
Suite F4 –Water samples VOC and SVOC	0
Suite F5 –Water samples PCB	0
Suite F6 –Water samples Hydrocarbon fuel identification	40
Suite F7 –Water samples Oxygen demand	40
Suite F8 –Water samples Other parameters	44
Suite F9 –Water samples NAPL	0

A full set of geo-environmental laboratory test certificates are provided within Appendix VIII. Some testing could not be completed in time for this report and will be issued as an addendum letter.

5. REFERENCES

British Geological Survey (BGS)

- BGS Sheet 228 *'Haverfordwest'* Solid and Drift edition at 1:50,000 scale.
- BGS online maps and lexicon database – www.bgs.co.uk

British Standards / Eurocode

- British Code of Practice BS 5930:2015 *'Code of Practice for Site Investigations'*
- British Code of Practice BS 1377:1990 *'Methods of test for soils for civil engineering purposes'.*
- British Code of Practice BS EN ISO 14688-1:2002+A2:2013 *'Geotechnical investigation and testing – Identification and classification of soil – Part 1: Identification and description'*
- British Code of Practice BS EN ISO 14688-2:2004+A2:2013 *'Geotechnical investigation and testing – Identification and classification of soil – Part 2: Principles for a classification'*
- British Code of Practice BS EN ISO 22475-1:2006 *'Geotechnical investigation and testing – Sampling methods and groundwater measurements'*
- British Code of Practice BS EN ISO 22476-3:2005+A1:2011 *'Geotechnical investigation and testing – Field Testing – Part 3: Standard penetration test'*

Institution of Civil Engineers (ICE)

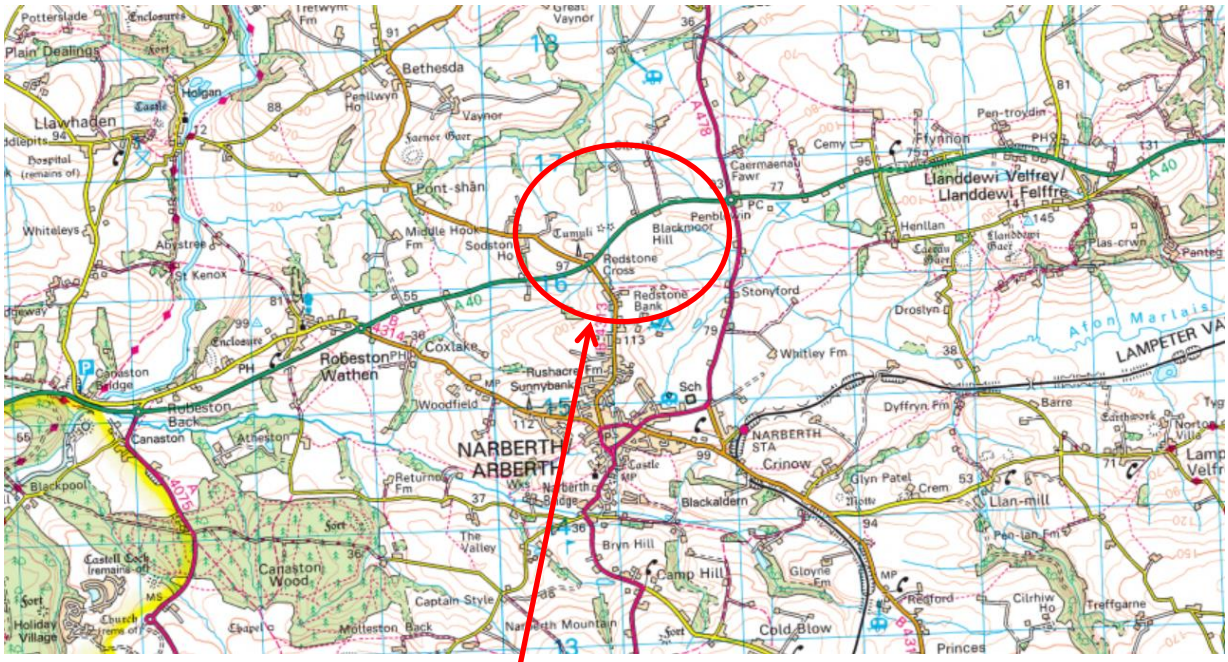
- UK Specification for Ground Investigation, Second Edition (2012)

Specialist Publications

- CIRIA Report 143 (1995) *'The Standard Penetration Test (SPT): Methods and Use'*
- BRE Special Digest 1 3rd Edition (2005) *'Concrete in aggressive ground'*
- Health and Safety Executive Guidance Note EH40/90

APPENDIX I – SITE PLANS AND FIGURES

- **Figure 1:** *Site Location Plan*
- **Figure 2:** *Site Overlay Plan*
- **Figure 3a to 3d**: *Exploratory Hole Location Plans*



The Site

Mapping sourced from www.bing.com

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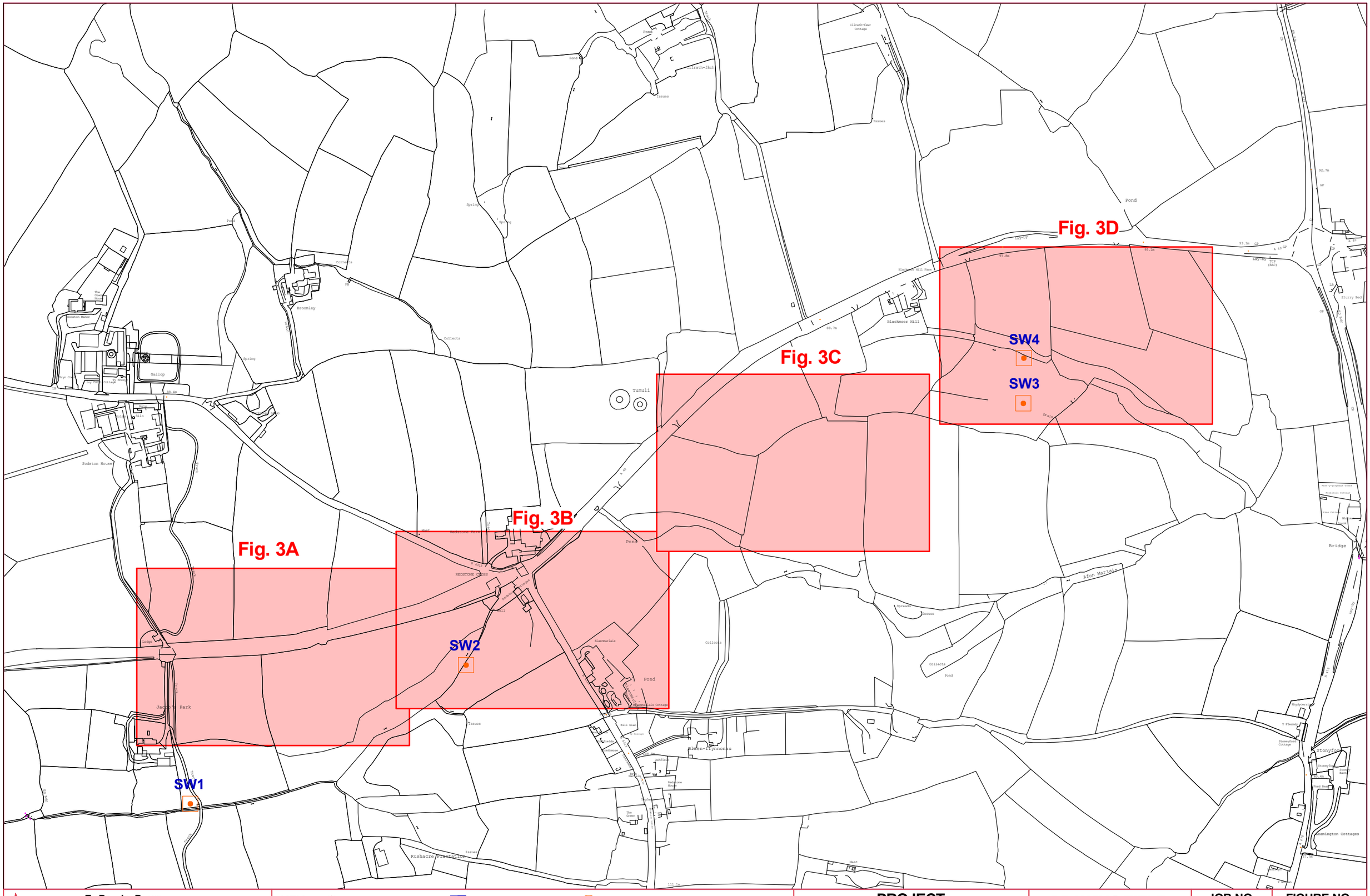
FIGURE 1
Project: A40 Redstone Cross to Pemblewin

Job No: Q0083

Drawing Title: Site Location Plan



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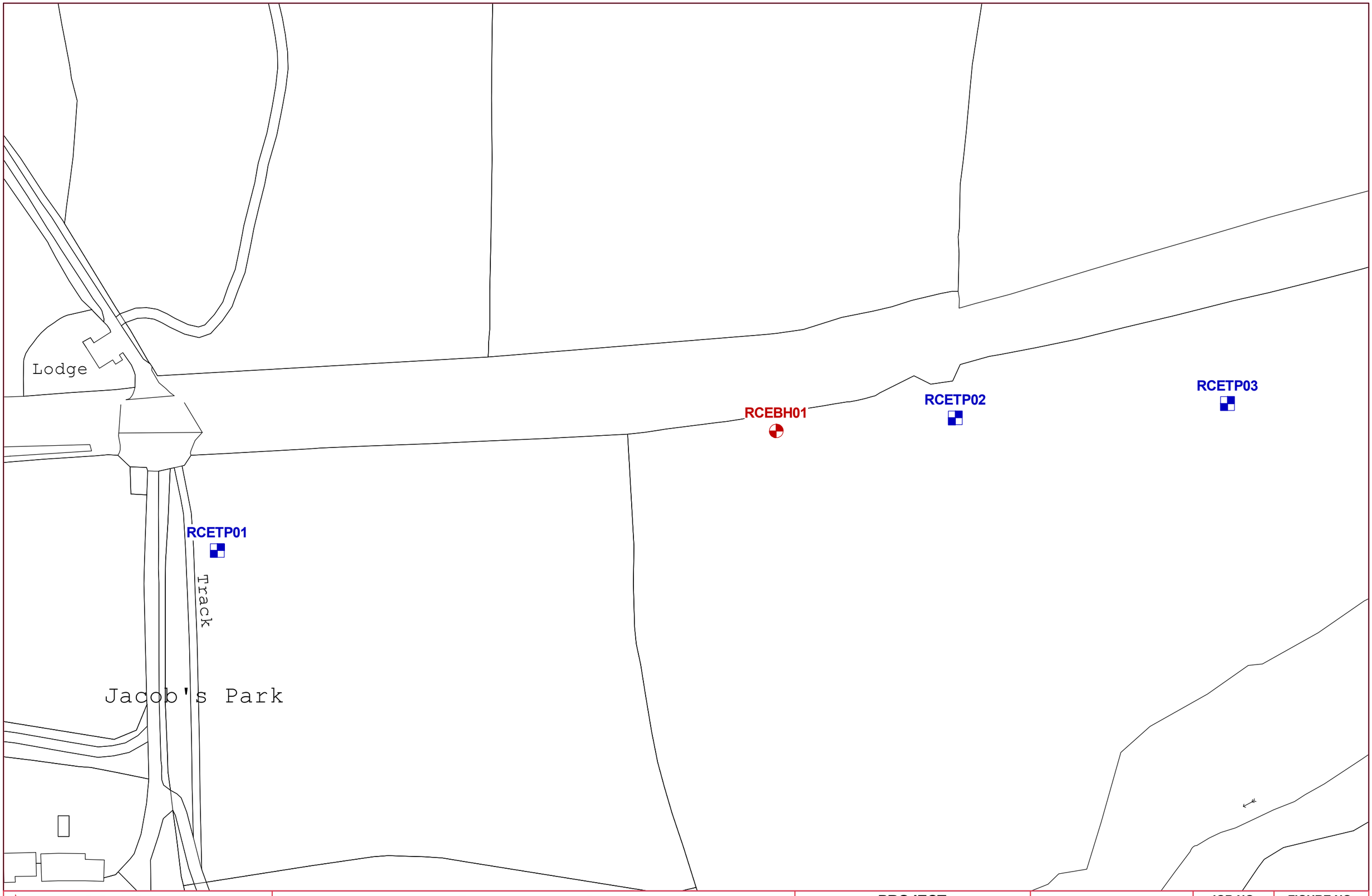
KEY
Borehole
Trial Pit
Monitoring / Test Point
Window Sample
Dynamic Probe
Historical Hole
Sampling Point

PROJECT
A40 RCE & LVP BY PASS

DRAWING TITLE:
EXPLORATORY HOLE LOCATION PLAN

JOB NO.	FIGURE NO.
Q0083	3
DATE	SCALE
26/11/19	1:5000



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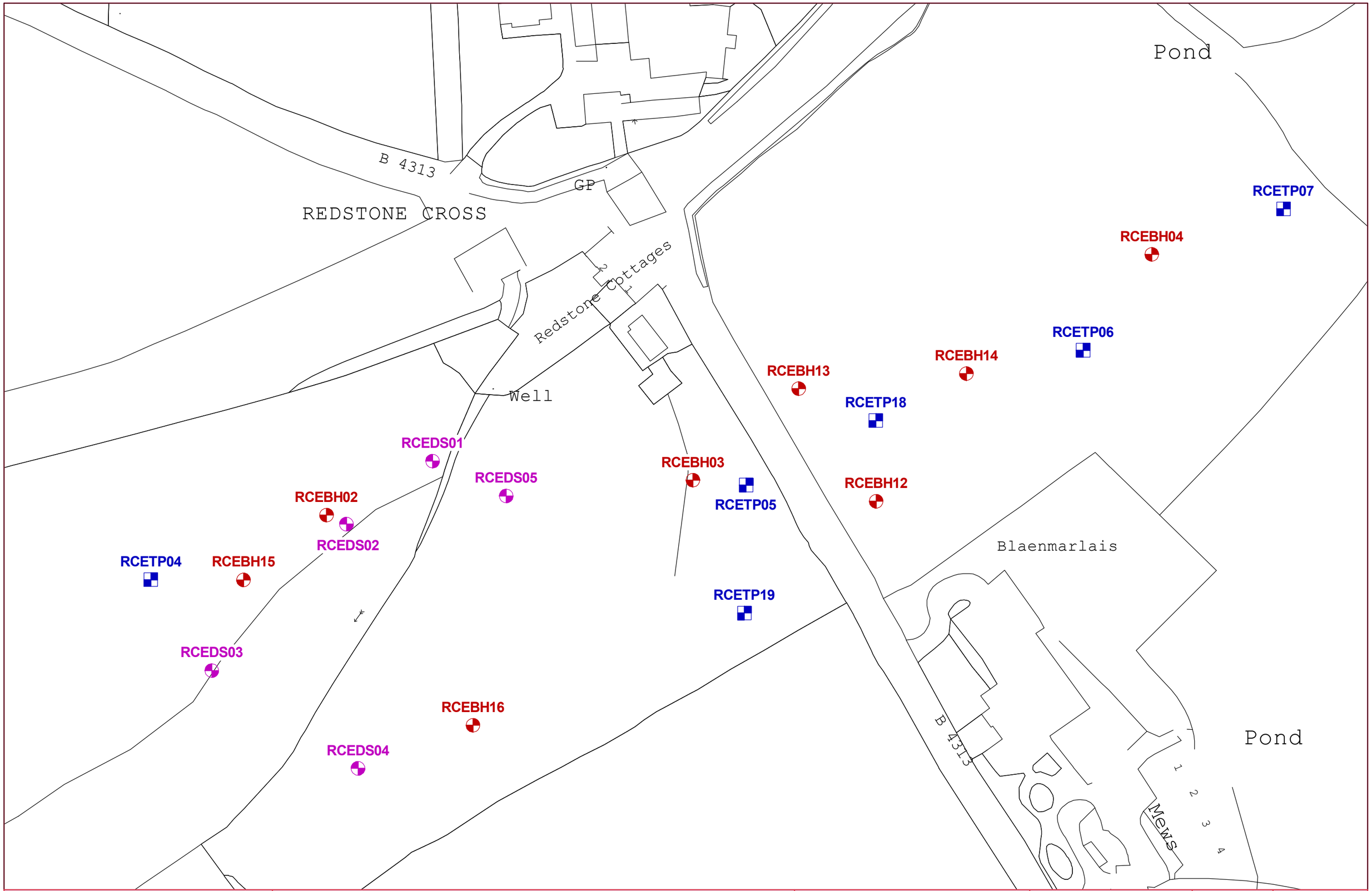
PROJECT
A40 RCE & LVP BY PASS

DRAWING TITLE:
EXPLORATORY HOLE LOCATION PLAN

JOB NO.	FIGURE NO.
Q0083	3A
DATE	SCALE
27/11/19	1:1000



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PROJECT
A40 RCE & LVP BY PASS

DRAWING TITLE:
EXPLORATORY HOLE LOCATION PLAN

JOB NO.	FIGURE NO.
Q0083	3B
DATE	SCALE
27/11/19	1:1000

RCETP10

RCEBH07

RCETP09

RCEBH06

RCETP08

RCEDS08

RCEDS09

RCEBH5CP

RCEDS06a

RCEBH05ROT

RCEDS06b

RCEDS07

RCEDS10

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KEY

Borehole | Trial Pit | Monitoring / Test Point

Window Sample | Dynamic Probe | Historical Hole | Sampling Point

PROJECT
A40 RCE & LVP BY PASS

DRAWING TITLE:
EXPLORATORY HOLE LOCATION PLAN

JOB NO.	FIGURE NO.
Q0083	3C
DATE	SCALE
27/11/19	1:1000

97.8m

95.1m

RCETP15

RCEBH11

RCETP14

RCEBH10

RCETP13

RCEBH09

RCETP11

RCEBH08

RCETP12

RCESA12

Drain

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KEY
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Trial Pit
Monitoring / Test Point
Window Sample
Dynamic Probe
Historical Hole
Sampling Point

PROJECT
A40 RCE & LVP BY PASS

DRAWING TITLE:
EXPLORATORY HOLE LOCATION PLAN

JOB NO.	FIGURE NO.
Q0083	3D
DATE	SCALE
27/11/19	1:1000

APPENDIX II – ENGINEERING GEOLOGIST'S BOREHOLE LOGS

KEY TO BOREHOLE AND TRIAL PIT LOGS

m.A.O.D. metres Above Ordnance Datum.

SAMPLE AND TEST TYPES

U	Undisturbed driven tube sample - 102mm diameter, 450mm long.
P	Undisturbed pushed piston sample - 102mm diameter, 1000mm long.
TW	Undisturbed thin walled push in sample - 100mm diameter, 750mm long.
B	Bulk disturbed sample.
BLK	Block Sample
CBR	Heavy duty undisturbed sample - 154 mm diameter (CBR mould).
D	Small disturbed sample.
LB	Large Bulk disturbed sample (for earthworks testing)
C	Core sample
W	Water sample
G	Gas sample
ES	Environmental sample (soil)
j	Jar sample
t	Tub sample
p	Pot sample
s	Small sample
v	Vial sample
S	Standard Penetration Test using split spoon sampler. (See Note).
C	Standard Penetration Test using a solid 60 degree cone. (See Note).

NOTE: Where a single value is quoted this is the N value for 300 mm penetration following a seating drive of 150 mm. Where this full penetration is not achieved the number of blows is quoted for the penetration below the seating drive eg. 63/160 mm.
Where total penetration is less than the seating drive this is indicated by a + and the number of blows for total penetration is quoted eg. +50/75 mm.

HV	Hand Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
V	Borehole Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
FHT/RHT	Falling / Rising Head Permeability Test.

CORE RUN DETAILS

TCR	Total Core Recovery, %
SCR	Solid Core Recovery, %
RQD	Rock Quality Designation, %
FI	Fracture Index. NI - Non intact where > 25 No. per metre length.

WATER COLUMN SYMBOLS

	First water strike, second water strike etc.
	Standing water level after first strike, second strike etc.
	Seepage.

NOTE:
Legend symbols in accordance with BS 5930 (2015)

KEY TO BOREHOLE AND TRIAL PIT LOGS

MATERIAL LEGENDS

Made Ground	Topsoil	Clay
Gravel	Sand	Silt
Peat	Boulders	Cobbles
Chalk	Conglomerate	Volcaniclastic
Asphalt	Void	Mudstone
Siltstone	Sandstone	Limestone
Ironstone	Mudstone / Siltstone	Breccia
Coal	Coral	Bedrock
Shale	Gypsum	Igneous (Coarse Grained)
Igneous (Fine Grained)	Igneous (Medium Grained)	Metamorphic (Coarse Grained)
Metamorphic (Fine Grained)	Metamorphic (Medium Grained)	

INSTALLATION / BACKFILL DETAILS

Arisings	Concrete	Bentonite cement grout
Bentonite seal	Filter	Pea Gravel
Plain pipe	Slotted pipe	Piezometer / Standpipe tip

NOTE:
Legend symbols in accordance with BS 5930 (2015)

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH01

Dates : 17/9/19 - 18/9/10

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 87.97 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210521.43 E 216044.73 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.30)	Dark brown slightly sandy slightly grqavelly SILT. Sand is fine to coarse. Gravel is subrounded fine to coarse of sanstone. (TOPSOIL)		(0.30)		
											0.30					
											(0.70)			(0.70)		
1	1.00	10	0	0			1	SPT (C) 100/180mm (3-7-**19-30-51/30mm**-)			1.00	Light brown clayey GRAVEL with low cobble content. Gravel is angular to subangular fine to coarse of sandstone. Cobbles are subangular of sandstone. (Probable Weathered Bedrock) 1.00-3.50m: Very poor recovery, recovered as angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss.				
2	2.00	0	0	0			2	SPT (C) 80/85mm (10-15-**40-40/10mm**--)								
	2.50						2.5	SPT (C) 100/116mm (25/40mm-**41-59/41mm**--)								
3		20	0	0												
	3.50						3.5	SPT (C) 100/62mm (25/11mm-**100/62mm**---)				Strong light grey/light brown fractured SANDSTONE. Weathering; Slight, with some very locaised weakening on fracture planes and some brown staining. Factures; Subhorizontal open clean rough stepper and planar 3.50-4.50m: Slightly stronger rock with slightly darker grey colour.				
4		62	45	11	NI 70 110											
	4.50															
5		59	35	0	NI 30 95											
	5.50										(9.00)	5.58-6.50m: Very poor recovery, recovered as angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss.		(9.00)		
6		20	20	0	NI 40 87											
	6.50						6.5	SPT (C) 100/40mm (25/11mm-**100/40mm**---)				6.70-6.80m: Very poor recovery, recovered as angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss.				
7		97	67	27	NI 60 280							7.62-8.00m: Very poor recovery, recovered as				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
2.25	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed
1.00		No groundwater encountered	

Flush

Depth	Type	Returns
0.00 - 10.00	Air Mist	

Remarks: MC305 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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email:

Operator:	Logged By.	Sheet No.	m Per Page
RB	HW	1 Of 2	8

All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH01

Dates : 17/9/19 - 18/9/10

Job Number : Q0083

Location : RCE

Engineer : ARUP

Ground Level : 87.97 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210521.43 E 216044.73 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8	8.00											angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss. Strong light grey/light brown fractured SANDSTONE. Weathering; Slight, with some very locaised weakening on fracture planes and some brown staining. Factures; Subhorizontal open clean rough stepper and planar				
		81	30	23	NI 60 230											
9	9.00															
		50	42	0	NI 45 90		9.5	SPT (C) 100/30mm (25/22mm-**100/30mm**---)								
10	10										10.00	8.17-8.32m: Very poor recovery, recovered as angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss. 9.30-10.00m: Very poor recovery, recovered as angular to subangular fine to coarse gravel. Anticipated Zone of Core Loss. Terminated at scheduled depth				
11																
12																
13																
14																
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC305 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
RB	HW	2 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH01

Dates : 17/9/19 - 18/9/10	Job Number : Q0083	Ground Level : 87.97 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210521.43 E 216044.73 N *Co-ordinates to National Grid*

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email:

Operator:	Logged By.	Sheet No.	m Per Page	
RB	HW	1 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH01

Dates : 17/9/19 - 18/9/10	Job Number : Q0083	Ground Level : 87.97 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210521.43 E 216044.73 N *Co-ordinates to National Grid*

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email:

Operator:	Logged By.	Sheet No.	m Per Page	
RB	HW	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH02

Dates : 18/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.60 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210770.60 E 216073.89 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Brown slightly gravelly sandy Clay. (TOPSOIL)		(0.30)		
									0.50 - 0.80	B2	0.30 (0.50)	Grey brown clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		(0.50)		
1							1.2	SPT (C) 37 (5-7-**8-9-10-10**)	1.00	ES3	0.80	Dense pale brown grey slightly clayey slightly sandy GRAVEL. Gravel is angular fine to coarse mudstone.				
									1.20 - 2.00	B5	(1.50)			(1.50)		
2							2	SPT (C) 50/100mm (14-11/30mm-**31-19/25mm**--)	2.00	ES7						
							2.3	SPT (C) 50/85mm (25-**40-10/10mm**--)			2.30	Very poor recovery; Probable dark grey MUDSTONE; recovered as subangular to subrounded fine to coarse gravel and clayey gravel.				
	2.50															
3		30	0	0												
	3.50						3.5	SPT (S) 50/160mm (7-10-**15-25-10/10mm**-)			(2.50)			(2.50)		
4		40	0	0												
	4.50						4.5	SPT (S) 50/50mm (25/61mm-**50/50mm**---)			4.80	Poor recovery; Very weak brown and grey interbedded MUDSTONE; recovered as angular fine to coarse gravel.			1	
5		75	49	0												
	5.50										(1.70)			(1.70)		
6		79	41	0	NI 20 110											
	6.50										6.50	Very poor recovery; Weak dark grey MUDSTONE/SILTSTONE; recovered as subrounded fine to coarse gravel.				
7		70	20	0												
	7.50						7.5	SPT (C) 100/145mm (9-16/60mm-**31-69/70mm**--)								
		10	0	0												

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
18/09/2019 17:00	2.30	1.50	DRY

Casing

Depth	Diam.
2.50	115.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns
0.00 - 12.50	Air Mist	

Remarks: Dando2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page
PO&SW	A Jones	1 Of 2	8

All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH02

Dates : 18/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.60 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210770.60 E, 216073.89 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	Fractures: FI	Insitu Tests: Depth	Insitu Tests: Test Results	Samples: Depth	Samples: Type No. Blows	Strata: Depth (Thick-ness)	Strata: Description	Strata: Legend	Red. Level A.O.D.	Water	Install/ Backfill
8												Very poor recovery; Weak dark grey MUDSTONE/SILTSTONE; recovered as subrounded fine to coarse gravel.				
	8.50	10	0	0							(4.50)			(4.50)		
9		0	0	0												
	9.50	40	0	0			9.5	SPT (C) 100/47mm (25/60mm-**100/47mm**---)								
10	10.00	76	0	0												
	10.50	54	30	0			10.5	SPT (C) 100/49mm (25/47mm-**100/49mm**---)								
11	11.00										11.00	11.00-11.47m: Nonintact recovered as angular fine to coarse gravel				
		100	81	0							(1.50)	Weak dark grey MUDSTONE. Weathering; Moderate, some weakening of the rock matrix and brown staining on most fractures. Fracture set 1 Subhorizontal openand closed, closely spaced, smooth planar with brown staining		(1.50)		
12	12.5										12.50	12.20-12.41m: Nonintact recovered as angular fine to coarse gravel				
13												Terminated at scheduled depth				
14																
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
20/09/2019 07:30	12.50	4.50	5.50

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
12.50	5.50	Fast	

Flush

Depth	Type	Returns

Remarks: Dando2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
PO&SW	A Jones	2 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH02

Dates : 18/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 93.60 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210770.60 E 216073.89 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
PO&SW	A Jones	1 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH02

Dates : 18/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 93.60 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210770.60 E 216073.89 N *Co-ordinates to National Grid*

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email:

Operator:	Logged By.	Sheet No.	m Per Page	
PO&SW	A Jones	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH03

Dates : 3/9/19 - 6/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 100.06 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210878.08 E 216084.14 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.40)	Brown sandy slightly gravelly Clay/Silt with many rootletts. (TOPSOIL)		(0.40)		
											0.40 (0.30)	Brown slightly silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		(0.30)		
1	1.00	100	5	0							0.70	Very weak occasionally thinly laminated grey and dark grey MUDSTONE. Weathering; Moderate becoming slight below 6.0m, some localised weakening of the rock along fractures and brown staining. Fractures; Sunhorizontal, open clean smooth planar				
2	2.00	29	1	0	30 35 40	38	2	SPT (C) 100/80mm (25/55mm-**62-38/5mm**--)								
3																
	3.50	80	15	0	20 60 70	12	3.5	SPT (C) 100/35mm (25/10mm-**100/35mm**---)				3.50-4.50m: No recovery				
4																
	4.50	100	51	13	10 30 100	39						4.50-5.06m: Nonintact recovered as angular fine to coarse gravel				
5					10 20 100	24										
6	6.00	89	39	8	20 60 120	22	6	SPT (C) 100/10mm (25/5mm-**100/10mm**---)			(11.30)			(11.30)		
7																
	7.50	90	25	10	20 70 100	22						7.26-7.50m: Nonintact recovered as angular fine to coarse gravel 7.70-8.50m: Nonintact recovered as angular fine to				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
1.00	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed
4.00	3.50	Seepage	

Flush

Depth	Type	Returns
0.00 - 12.00	Air Mist	

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	AP	1 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH03

Dates : 3/9/19 - 6/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 100.06 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210878.08 E 216084.14 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8												coarse gravel				
	8.50	90	25	10	20 70 100	22	8.5	SPT (C) 100/10mm (25/20mm-**100/10mm**---)				Very weak occasionally thinly laminated grey and dark grey MUDSTONE. Weathering; Moderate becoming slight below 6.0m, some localised weakening of the rock along fractures and brown staining. Fractures; Sunhorizontal, open clean smooth planar				
9		98	46	34	10 60 170	17										
	9.50															
10		98	70	54	20 100 170	10										
	10.50															
11		100	73	29	90 120 220	7										
					20 80 100	13										
12	12						12	SPT (C) 100/10mm (25/15mm-**100/10mm**---)			12.00	Terminated at scheduled depth				
13																
14																
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
05/09/2019 07:30	10.50	1.00	9.80

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH03

Dates : 3/9/19 - 6/9/19	Job Number : Q0083	Ground Level : 100.06 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210878.08 E 216084.14 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH03

Dates : 3/9/19 - 6/9/19	Job Number : Q0083	Ground Level : 100.06 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210878.08 E 216084.14 N *Co-ordinates to National Grid*

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GB	AP	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH04

Dates : 9/9/19 - 16/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 100.61 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211012.70 E 216150.36 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Orange brown slightly silty slightly gravelly sandy CLAY. (TOPSOIL)		(0.30)		
									0.50 - 1.00	B2	0.30					
											(0.70)	Grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. (Weathered mudstone)		(0.70)		
1							1	SPT (C) 50/215mm (18-7/30mm-**21-25-4/65mm**-)	1.00	ES3	1.00					
									1.20 - 1.50	B5						
							1.5	SPT (C) 50/135mm (25/70mm-**26-24/60mm**--)			(1.00)	Grey and brown MUDSTONE; recovered as slightly clayey GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		(1.00)		
2	2.00	90	80	0							2.00	2.00-2.30m: Nonintact recovered as angular fine to coarse gravel				
3	3.00	71	71	13								Weak dark grey MUDSTONE loaclly grading to a SILTSTONE. Some laminations and lenses of light brown mudstone seen. Weathering; Moderate, some weakening of the rock matrix and brown staining on the factures. Fracture set 1 subhorizontal (20-35 degree) planar rough and smooth clean with brown staining on surfaces. 3.40-3.80m: Nonintact recovered as angular fine to coarse gravel, AZCL				
4	4.00	87	60	0								4.00-4.40m: Nonintact recovered as angular fine to coarse gravel, AZCL				
5	5.00	100	50	22			5	SPT (C) 100/94mm (25/18mm-**29-71/19mm**--)				5.00-5.30m: Nonintact recovered as angular fine to coarse gravel			1	
6	6.00	87	53	0								5.43-5.60m: Nonintact recovered as angular fine to coarse gravel 5.92-5.98m: Nonintact recovered as angular fine to coarse gravel				
7												6.19-6.31m: Nonintact recovered as angular fine to coarse gravel			1	
	7.50	100	52	21								6.38-6.47m: Nonintact recovered as angular fine to coarse gravel 7.50-7.80m: Nonintact recovered as angular fine to				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
2.00	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed
7.20	6.75	Medium flow	

Flush

Depth	Type	Returns
1.50 - 14.00	Air Mist	

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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SW	AJ	1 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH04

Dates : 9/9/19 - 16/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 100.61 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211012.70 E 216150.36 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8											(12.00)	coarse gravel Weak dark grey MUDSTONE loaclly grading to a SILTSTONE. Some laminations and lenses of light brown mudstone seen. Weathering; Moderate, some weakening of the rock matrix and brown staining on the factures. Fracture set 1 subhorizontal (20-35 degree) planar rough and smooth clean with brown staining on surfaces. 8.03-8.10m: Nonintact recovered as angular fine to coarse gravel 8.20-8.27m: Nonintact recovered as angular fine to coarse gravel 8.44-9.04m: Nonintact recovered as angular fine to coarse gravel 9.00-9.29m: Nonintact recovered as angular fine to coarse gravel 11.10-11.19m: Nonintact recovered as angular fine to coarse gravel, AZCL 12.08-12.24m: Nonintact recovered as angular fine to coarse gravel		(12.00)		
9	9.00	100	52	21			9	SPT (C) 100/30mm (25/30mm-**100/30mm**---)								
10		100	82	29												
11	10.50	97	80	37												
12	12.00	100	91	22			12	SPT (C) 100/18mm (25/9mm-**100/18mm**---)								
13	13.50	100	78	0								13.60-13.71m: Nonintact recovered as angular fine to coarse gravel				
14	14						14	SPT (C) 100/9mm (25/10mm-**100/9mm**---)			14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
13/09/2019 07:30	14.00	2.00	2.30

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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SW	AJ	2 Of 2	8	All measurements in metres unless otherwise stated

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH04

Dates : 9/9/19 - 16/9/19	Job Number : Q0083	Ground Level : 100.61 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211012.70 E 216150.36 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
SW	AJ	1 Of 3	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH04

Dates : 9/9/19 - 16/9/19	Job Number : Q0083	Ground Level : 100.61 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211012.70 E 216150.36 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
SW	AJ	2 Of 3	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH04

Dates : 9/9/19 - 16/9/19	Job Number : Q0083	Ground Level : 100.61 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211012.70 E 216150.36 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
SW	AJ	3 Of 3	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH5CP

Dates : 13/9/19 - 16/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 89.74 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211168.10 E 216251.78 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No. Blows	Insitu Test Results Depth	Insitu Test Results	Strata Depth (Thick-ness)	Strata Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0					(0.30)	Dark brown sandy slightly gravelly SILT. Sand is fine to coarse. Gravel is subrounded of sandstone. (TOPSOIL)		(0.30)		
	0.30	ES 1			0.30	Firm becoming very stiff light brown slightly sandy slight gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse. Cobbles are subangular to subrounded of sandstone.				
	0.50 - 1.00	B 2								
1	1.00	ES 3								
	1.20 - 1.65	UT 4 - 55/100%								
	1.65 - 1.70	D 5	1.7	SPT (S) 12 (3-4-**4-2-3**)						
2	2.00	ES 6								
	2.00 - 2.45	UT 7 - 70/100%							1	
	2.45 - 2.50	D 8	2.5	SPT (S) 19 (3-5-**6-5-4-4**)						
	2.50 - 3.00	B 9								
3	3.00 - 3.45	UT 10 - 91/100%			(5.20)			(5.20)		
			3.5	SPT (S) 50 (3-5-**7-7-18-18**)						
4	4.00 - 4.00	B 11								
	4.50 - 5.00	B 12	4.5	SPT (S) 35 (5-7-**9-9-8-9**)						
5	5.00 - 5.45	UT 13 - 120/100%								
	5.45	D 5.5	5.5	SPT (S) 50/70mm (25/50mm-**50/70mm**---)	5.50	See RCEBH05ROT for further details. Unable to progress deeper.			1	
6										
7										

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
13/09/2019 16:30	3.00	3.00	DRY
16/09/2019 08:00	3.00	3.00	DRY
16/09/2019 12:00	5.50	5.00	2.60

Casing

Depth	Cas. Dia.
5.00	115.00

Groundwater

Struck	Rose To	Behaviour	Sealed
5.50	2.10	Medium	

Chiselling

From	To	Hours
5.40	5.50	1:00

Remarks: Dando 2000

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PO&SW	AJ	1 Of 1	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH05ROT

Dates : 10/9/19 - 11/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 89.73 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211173.90 E 216251.20 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0												See RCEBH05CP for shallow details Rotary Open Hole				
1							1	SPT (C) 8 (2-2-**2-2-2-2**)								
2																
							2.5	SPT (C) 18 (3-3-**4-4-5-5**)							1	
3											(5.50)			(5.50)		
4							4	SPT (C) 25 (4-4-**5-7-6-7**)							1	
5																
	5.50						5.5	SPT (C) 24 (3-3-**3-7-7-7**)			5.50	Stiff brown gravelly CLAY. Gravel is angular fine to coarse of mudstone (probable weathered Bedrock)				
6		67	0	0							(1.50)			(1.50)		
7	7.00						7	SPT (C) 100/235mm (8-8-**12-21-39-28/10mm**)			7.00	Description on next page				
		67	23	0	NI 60 70							7.21-7.31m: Nonintact recovered as angular fine to coarse gravel 7.63-7.84m: Nonintact recovered as angular fine to				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
5.00	115.00

Groundwater

Struck	Rose To	Behaviour	Sealed
4.10	2.60	MEDIUM FLOW	

Flush

Depth	Type	Returns

Remarks: MC450 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH05ROT

Dates : 10/9/19 - 11/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 89.73 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211173.90 E 216251.20 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8												coarse gravel				
		67	23	0	NI 60 70							Moderately weak and occasionally strong dark grey/black SILTSTONE. Weathering, Slight, with some reduction of rock stength on fractures and brown staining on the fractures. Fracture set 1 45 degree to subvertical smooth planar open and closed clean				
	8.50															
9		100	61	12	NI 60 120											
	9.50						9.5	SPT (C) 100/32mm (25/40mm-**100/32mm**---)								
10		50	40	0	NI 30 70							9.50-10.50m: Nonintact recovered as angular fine to coarse gravel, AZCL				
	10.50										(7.00)			(7.00)		
		100	60	0	NI 30 40							10.50-10.63m: Nonintact recovered as angular fine to coarse gravel				
11	11.00											10.74-10.87m: Nonintact recovered as angular fine to coarse gravel				
		61	60	0	NI 25 50							11.00-11.75m: Nonintact recovered as angular fine to coarse gravel, AZCL				
12	12.00						12	SPT (C) 100/22mm (25/16mm-**100/22mm**---)								
		140	90	0	NI 40 60											
	12.50											12.50-13.00m: Nonintact recovered as angular fine to coarse gravel, AZCL				
13		70	45	0	NI 60 75											
	13.50											13.50-14.00m: Multiple cross fracturing				
		90	90	0	NI 45 70											
14	14										14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
11/09/2019 07:30	10.50	7.00	2.40

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC450 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer

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GB	HW	2 Of 2	8	

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH05ROT

Dates : 10/9/19 - 11/9/19	Job Number : Q0083	Ground Level : 89.73 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211173.90 E 216251.20 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	1 Of 2	2	All measurements in metres unless otherwise stated

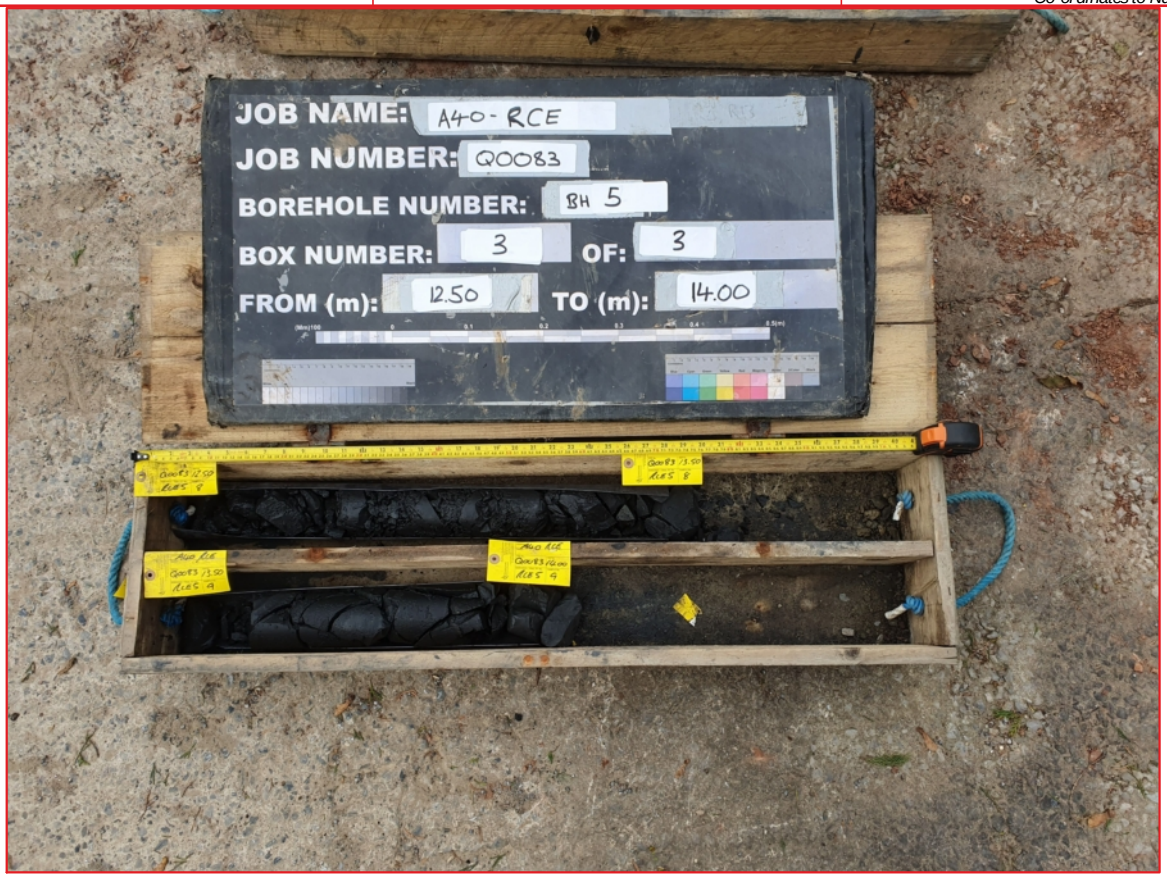
AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH05ROT

Dates : 10/9/19 - 11/9/19	Job Number : Q0083	Ground Level : 89.73 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211173.90 E 216251.20 N *Co-ordinates to National Grid*



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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH06

Dates : 10/9/19 - 12/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 88.88 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211215.85 E 216285.68 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Brown slightly sandy slightly gravelly Clay. (TOPSOIL)		(0.30)		
									0.50	B2	0.30	Firm becoming stiff pale brown slightly sandy slightly gravelly CLAY.				
1									1.00	ES3						
									1.20	UT4						
							1.7	SPT (S) 14 (2-4-**3-3-4-4**)	1.65 - 1.70	D5						
									1.70	SPTLS6						
2									2.00	ES7 UT8	(3.40)			(3.40)		
							2.5	SPT (S) 17 (1-3-**5-4-3-5**)	2.45 - 2.50	D9						
									2.50	SPTLS10						
									2.50 - 3.00	B11						
3									3.00 - 3.45	UT12						
							3.5	SPT (S) 50/230mm (2-2-**4-21-22-3/5mm**)	3.45 - 3.50	D13						
									3.50	SPTLS14						
									3.50 - 4.00	B15	3.70	Stiff and very stiff pale brown slightly sandy slightly gravelly CLAY with low cobble and boulder content of mudstone.				
4									4.00 - 4.45	UT16						
							4.5	SPT (S) 27 (5-6-**6-7-7-7**)	4.45 - 4.50	D17	(1.30)			(1.30)	1	
									4.50	SPTLS18						
									4.50 - 5.00	B19						
5									5.00 - 5.45	UT20	5.00	Dense pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.				
							5.5	SPT (S) 38 (6-6-**7-10-9-12**)	5.50	SPTLS21	(0.70)			(0.70)	2	
									5.50 - 6.00	B22	5.70	Dense pale brown clayey slightly sandy GRAVEL with low cobble and boulder content of mudstone. Gravel is angular to sub angular fine to coarse mudstone.				
6									6.30 - 6.50	B23	(0.80)			(0.80)	3	
							6.5	SPT (C) 50/125mm (25/60mm-**27-23/50mm**--)			6.50	Very poor recovery: Probable MUDSTONE (highly weathered and fractured); Recovered as angular fine to coarse gravel.				
7	7.00	7	0	0			7	SPT (C) 26 (4-4-**6-6-7-7**)			(2.00)			(2.00)		

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
5.50	4.70	Medium Ingress from 4.7mbgl	
6.20	5.40	Medium water ingress at 6.2mbgl	

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH06

Dates : 10/9/19 - 12/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 88.88 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211215.85 E 216285.68 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8		7	0	0												
	8.50						8.5	SPT (C) 29 (5-5-**6-7-8-8**)			8.50	Very poor recvovery; Probable boulder clay; recovered as brown clayey sandy GRAVEL. Sand is fine to coarse. Gravel is subrounded fine to coarse of sandstone.				
9		10	0	0	NI 0 0						(1.30)			(1.30)		
	9.50	20	0	0	NI 10 20						9.80	Very poor recovery: Moderately weak dary grey SILTSTONE with occasional sandy beds up to 30mm thick. Sandy beds are strong. Weathering; Difficult to determine, what is recovered appears slightly weathered with a little surface staining seen. Fracture sets; Subhorizontal open clean planar smooth.				
10	10.00	40	20	0	NI 12 30		10	SPT (C) 100/50mm (25/15mm-**100/50mm**---)								
11	11.00	60	30	0	NI 11 17											
	11.50															
12		32	22	0	NI 10 15						(4.20)			(4.20)		
	12.50	58	36	0	NI 9 20		12.5	SPT (C) 100/10mm (25/5mm-**100/10mm**---)								
13	13.00	30	20	0	NI 10 30											
14	14										14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
12/09/2019 07:30	11.50	10.00	2.60

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH06

Dates : 10/9/19 - 12/9/19	Job Number : Q0083	Ground Level : 88.88 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211215.85 E 216285.68 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH07

Dates : 11/9/19 - 13/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 86.49 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211309.31 E 216358.26 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.25)	Brown slightly sandy slightly gravelly Clay. (TOPSOIL)		(0.25)		
									0.50 - 1.00	B2	0.25	Firm pale brown slightly sandy slightly gravelly CLAY.				
1									1.00	ES3						
									1.20 - 1.65	UT4						
							1.7	SPT (S) 15 (3-4-**4-4-3-4**)	1.65 - 1.70	D5						
2									2.00	ES6						
									2.00 - 2.45	UT7	(3.65)			(3.65)		
	2.30						2.5	SPT (S) 14 (2-2-**3-4-4-3**)	2.45 - 2.50	D8						
		80	71	0	NI 40 95				2.50 - 3.00	B9						
3									3.00 - 3.45	UT10						
	3.30						3.5	SPT (S) 16 (1-0-**0-4-4-8**)	3.45 - 3.50	D11						
		87	62	0	NI 40 90				3.50 - 4.00	B12						
4							4	SPT (S) 50/195mm (10-12-**15-15-20/45mm**-)	4.00 - 4.50	B13	3.90	Stiff and very stiff pale brown slightly sandy slightly gravelly CLAY with low cobble and boulder content of mudstone.				
	4.30										(1.40)			(1.40)		
5		100	87	0	NI 60 75		5	SPT (C) 36 (5-6-**8-8-9-11**)	5.00 - 5.50	B14	5.30	Dense pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.				
	5.80										(1.50)			(1.50)		
6		87	31	0	NI 0 94		6.5	SPT (C) 34 (4-4-**7-8-9-10**)	6.50 - 7.00	B15	6.80	Very dense pale brown clayey slightly sandy GRAVEL with low cobble and boulder content of mudstone. Gravel is angular to sub angular fine to coarse mudstone.				
7	7.30															
		100	75	0	NI 70 98											

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
13/09/2019 07:30	4.00	2.50	0.50

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH07

Dates : 11/9/19 - 13/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 86.49 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211309.31 E 216358.26 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8							8	SPT (C) 50 (8-8-**10-13-14-13**)	8.00 - 8.50	B16						
	8.80	100	75	0	NI 70 98						(3.20)	Very dense pale brown clayey slightly sandy GRAVEL with low cobble and boulder content of mudstone. Gravel is angular to sub angular fine to coarse mudstone.		(3.20)		
9		98	93	25	NI 90 210		9.5	SPT (C) 50/230mm (9-12-**15-16-16-3/5mm**)								
10	10.30										10.00	10.00-11.15m: Poor recovery Nonintact recovered as angular fine to coarse gravel. AZCL			1	
11		81	69	0	NI 55 70							Moderately weak and weak dark grey/black fractured MUDSTONE. Weathering; Light, little in the way of visual signs and no signs of weakening of rock Fractures; Subhorizontal open and closed planar smooth				
12	11.80	90	90	0	NI 65 98						(4.00)	11.45-11.65m: Poor recovery Nonintact recovered as angular fine to coarse gravel. AZCL 12.50-12.75m: Poor recovery Nonintact recovered as angular fine to coarse gravel. AZCL		(4.00)		
13	13.30	214	201	116	NI 82 360							13.60-13.70m: Nonintact recovered as angular fine to coarse gravel.				
14	14										14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
9.50	150.00

Groundwater

Struck	Rose To	Behaviour	Sealed
11.50	9.80	Medium	

Flush

Depth	Type	Returns
10.00 - 14.00	Air Mist	

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH07

Dates : 11/9/19 - 13/9/19	Job Number : Q0083	Ground Level : 86.49 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211309.31 E 216358.26 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH08

Dates : 19/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 80.39 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211492.09 E 216439.53 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Dark brown sandy slightly gravelly SILT. Sand is fine to coarse. Gravel is subrounded of sandstone. (TOPSOIL)		(0.30)		
									0.50 - 1.00	B2	0.30					
1									1.00	ES3	(1.70)	Stiff light brown slightly sandy slight gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse. Cobbles are subangular to subrounded of sandstone.		(1.70)		
									1.20 - 1.65	UT4						
							1.7	SPT (C) 31 (4-5-**7-8-8-8**)	1.65 - 1.70	D5						
2									2.00							
									2.20 - 2.65	UT6		Stiff dark grey brown sandy slight gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse. Cobbles are subrounded of sandstone.				
							2.7	SPT (C) 44 (9-10-**8-10-12-14**)	2.70 - 3.00	B7						
3											(2.10)			(2.10)		
									3.20 - 3.65	UT8						
									3.65 - 3.70	D9						
4							4	SPT (C) 50/140mm (11-14/55mm-**22-28/65mm**--)			4.10					
	4.50						4.5	SPT (C) 30 (3-6-**6-8-8-8**)				Very stiff brown and grey slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is subrounded fine to coarse of sandstone.				
5		13	0	0											1	
6	6.00						6	SPT (C) 35 (4-4-**8-9-9-9**)			(4.40)			(4.40)		
		3	0	0								6.50-7.50m: Borehole collapsing				
7																
	7.50						7.5	SPT (C) 100/65mm (12-13/30mm-**100/65mm**---)								
		30	0	0												

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
4.50	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns
4.50 - 15.00	Air Mist	

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH08

Dates : 19/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 80.39 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211492.09 E, 216439.53 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8		30	0	0												
	8.50										8.50	8.50-9.50m: Nonintact recovered as angular fine to coarse gravel				
9		90	0	0	NI 10 20						(1.40)	Very weak black/dark grey MUDSTONE (Heavily fractured) Weathering; Heavy, with weakening of the rock matrix and brown staining seen on most fractures		(1.40)		
	9.50										9.90					
10		63	30	0	NI 40 80							Moderately weak black/dark grey MUDSTONE (Heavily Fractured) Weathering; Slight, very localised weakening of the rock some brown staining on the fractures. Fracture Set 1 - Subhorizontal open clean planar and stepped rough and smooth Set 2 - subvertical to vertical open clean stepped smooth. 10.03-10.80m: Nonintact recovered as angular fine to coarse gravel. AZCL 11.30-11.42m: Nonintact recovered as angular fine to coarse gravel. AZCL 11.74-11.81m: Nonintact recovered as angular fine to coarse gravel. AZCL 12.00-12.70m: Heavily fractured with set 1 and 2 AZCL				
11	11.00						11	SPT (C) 100/85mm (18-7/0mm-**61-39/10mm**--)								
		100	60	0	NI 40 101											
12	12.00										(5.10)			(5.10)		
		80	80	7	NI 70 110											
13							13	SPT (C) 100/15mm (25/5mm-**100/15mm**---)								
	13.50															
14		87	87	32	NI 100 230											
15	15										15.00	14.80-15.00m: Nonintact recovered as angular fine to coarse gravel. AZCL Terminated at scheduled depth				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
19/09/2019 17:00	9.50	4.50	1.60
20/09/2019 07:30	9.50	4.50	1.50

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
8.50	5.30	Fast	

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH08

Dates : 19/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 80.39 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211492.09 E 216439.53 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH08

Dates : 19/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 80.39 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211492.09 E 216439.53 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH09

Dates : 16/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 78.10 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211539.69 E 216467.10 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.30)	Dark brown slightly sandy slightly gravelly SILT. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of sandstone. (TOPSOIL)		(0.30)		
											0.30					
1							1	SPT (C) 27 (3-4-**6-6-7-8**)				Stiff light brown slightly sandy slightly gravelly CLAY. Sand fine and coarse. Gravel is rounded to subrounded fine to coarse of sandstone.				
									1.60 - 2.00	B1	(2.20)			(2.20)		
2							2	SPT (C) 43 (8-9-**10-10-11-12**)	2.00	ES2						
									2.10 - 2.50	B3						
	2.50										2.50	2.50-3.50m: Nonintact recovered as angular fine to coarse gravel AZCL (Probable weathered bedrock)				
3		53	41	0	NI 20 80		3	SPT (C) 50/85mm (21-4/5mm-**36-14/10mm**--)								
							3.5	SPT (C) 50/85mm (25/10mm-**45-5/10mm**--)				Weak and moderately weak very dark grey MUDSTONE/SILTSTONE. Weathering; slight, some localised weakening of the rock and some white staining, below 9.0m little or no weathering. Fractures; Set 1 Subhorizontal to horizontal smooth planer open clean. Set 2 subhorizontal at 90degrees to set 1 smooth planar clean and open. Set 3 Occasional subvertical stepped rought open clean. 3.64-3.78m: Nonintact recovered as angular fine to coarse gravel 4.00-6.50m: Heavily fractured by set 1 and 2 5.00-5.38m: Nonintact recovered as angular fine to coarse gravel 5.55-5.69m: Nonintact recovered as angular fine to coarse gravel 6.17-6.80m: Nonintact recovered as angular fine to coarse gravel				
4	4.00	100	100	0	NI 40 80											
5	5.00	100	100	0	NI 60 70		5	SPT (C) 100/68mm (25/35mm-**100/68mm**---)								
6	6.50															
7		87	87	7	NI 90 112											

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
16/09/2019 17:00	4.00	2.50	0.50
17/09/2019 07:30	4.00	2.50	0.50

Casing

Depth	Diam.
2.50	150.00

Groundwater

Struck	Rose To	Behaviour	Sealed
1.60	1.60	Seep	
2.50	0.50		

Flush

Depth	Type	Returns
0.00 - 14.00	Air Mist	

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH09

Dates : 16/9/19 - 20/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 78.10 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211539.69 E 216467.10 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8	8.00															
							8.5	SPT (C) 100/35mm (25/10mm-**100/35mm**---)			(11.50)	Weak and moderately weak very dark grey MUDSTONE/SILTSTONE. Weathering; slight, some localised weakening of the rock and some white staining, below 9.0m little or no weathering. Fractures; Set 1 Subhorizontal to horizontal smooth planer open clean. Set 2 subhorizontal at 90degrees to set 1 smooth planar clean and open. Set 3 Occasional subvertical stepped rought open clean. 9.37-9.78m: Nonintact recovered as angular fine to coarse gravel		(11.50)		
9		75	71	0	NI 90 220											
10	10.00															
		100	95	0	NI 80 270											
11																
	11.50						11.5	SPT (C) 100/25mm (25/10mm-**100/25mm**---)				11.42-11.50m: Nonintact recovered as angular fine to coarse gravel				
12		93	90	7	NI 70 100							12.49-12.57m: Nonintact recovered as angular fine to coarse gravel				
13	13.00											12.63-12.79m: Nonintact recovered as angular fine to coarse gravel				
		100	89	31	NI 90 310											
14	14						14	SPT (C) 100/25mm (25/10mm-**100/25mm**---)			14.00	13.77-13.90m: Nonintact recovered as angular fine to coarse gravel Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
17/09/2019 17:00	11.50	8.50	0.50

Casing

Depth	Diam.
8.50	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in. Hydraulic hose burst and leaked over night, clean up undertaken in the morning.

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH09

Dates : 16/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 78.10 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211539.69 E 216467.10 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
PO+SW	AJ	1 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH09

Dates : 16/9/19 - 20/9/19	Job Number : Q0083	Ground Level : 78.10 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211539.69 E 216467.10 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH10

Dates : 25/9/19 - 26/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 90.96 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211730.96 E 216505.60 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.20)	Dark brown sandy SILT. Sand is fine to coarse. (TOPSOIL)		(0.20)		
											0.20	Weak brown and dark grey SILTSTONE (Heavily Fractured) Weathering; heavily weathered at the top becoming less weathered with depth. Many fractures and brown staining and waekening of the rock matrix. Facture set 1 Subhorizontal smooth and undulating and planar open and closed with browm staining. 1.00-1.40m: Nonintact recovered as angular fine to coarse gravel, AZCL 2.87-3.05m: Nonintact recovered as angular fine to coarse gravel 3.41-3.61m: Nonintact recovered as angular fine to coarse gravel				
1	1.00						1.5	SPT (C) 100/31mm (25/40mm-**100/31mm**---)								
		67	47	0												
2					NI 70 100						(3.41)			(3.41)		
	2.50															
3		99	87	57												
4	4.00						4	SPT (C) 100/10mm (25/30mm-**100/10mm**---)			3.61					
		100	87	57												
5	5.50											Moderately weak brown and light grey and dark grey thinly (50mm) bedded SILTSTONE. Weathering; Slight some brown staining on the fractures, no decernable reduction in rock strength. Fractures set 1 - Subhorizontal to 45 degree open smooth planar clean with occasional brown staining. 7.31-7.45m: Nonintact recovered as angular fine to coarse gravel				
6		100	100	43												
					NI 120 377											
7	7.00						7	SPT (C) 100/5mm (25/5mm-**100/5mm**---)								
		100	97	48												
8	8.50															
9		100	100	41							(12.39)			(12.39)		

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
1.00	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns
0.00 - 16.00	Air Mist	

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH10

Dates : 25/9/19 - 26/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 90.96 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211730.96 E 216505.60 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
10	10.00						10	SPT (C) 100/7mm (25/0mm-**100/7mm**---)				Moderately weak brown and light grey and dark grey thinly (50mm) bedded SILTSTONE. Weathering; Slight some brown staining on the fractures, no decernable reduction in rock strength. Fractures set 1 - Subhorizontal to 45 degree open smooth planar clean with occasional brown staining. 10.20-10.28m: Nonintact recovered as angular fine to coarse gravel 11.75-11.80m: Nonintact recovered as angular fine to coarse gravel 12.03-12.13m: Nonintact recovered as angular fine to coarse gravel 12.61-12.68m: Nonintact recovered as angular fine to coarse gravel 13.71-13.76m: Nonintact recovered as angular fine to coarse gravel 14.60-14.65m: Nonintact recovered as angular fine to coarse gravel 14.98-15.07m: Nonintact recovered as angular fine to coarse gravel 15.27-15.49m: Vertical open clean undulating fracture (possibly drill induced) 15.90-16.00m: Nonintact recovered as angular fine to coarse gravel Terminated at scheduled depth				
11		100	93	40												
	11.50															
12		100	90	40												
					NI											
13	13.00				120		13	SPT (C) 100/10mm (25/5mm-**100/10mm**---)								
					377											
		100	91	52												
14																
	14.50															
15		100	93	41												
16	16						16	SPT (C) 100/10mm (25/5mm-**100/10mm**---)			16.00					
17																
18																
19																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
25/09/2019 17:00	13.00	1.00	DRY
26/09/2019 07:30	13.00	1.00	DRY

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	2 Of 2	10	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH10

Dates : 25/9/19 - 26/9/19	Job Number : Q0083	Ground Level : 90.96 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211730.96 E 216505.60 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	All measurements in metres unless otherwise stated
GB	HW	1 Of 3	2	

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH10

Dates : 25/9/19 - 26/9/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 90.96 m A.O.D.
Level to Ordnance Datum

Coordinates: 211730.96 E
216505.60 N
Co-ordinates to National Grid

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	2 Of 3	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH10

Dates : 25/9/19 - 26/9/19	Job Number : Q0083	Ground Level : 90.96 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211730.96 E 216505.60 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	3 Of 3	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH11

Dates : 23/9/19 - 25/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211811.51 E 216529.07 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.20)	Dark brown sandy SILT. Sand is fine to coarse. (TOPSOIL)		(0.20)		
											0.20	Weak brown and grey interbedded MUDSTONE. Weathering; Heavy, weakening of the rock mass and staining on all suraces in some laters of rock. Fractures; Set 1 Subhorizontal open and closed plannar smooth. 1.00-1.30m: Nonintact recovered as angular fine to coarse gravel. 1.43-1.49m: Nonintact recovered as angular fine to coarse gravel. 1.62-1.71m: Nonintact recovered as angular fine to coarse gravel. 2.80-3.20m: Nonintact recovered as angular fine to coarse gravel, AZCL. 3.67-3.79m: Nonintact recovered as angular fine to coarse gravel. 4.00-4.60m: Nonintact recovered as angular fine to coarse gravel.				
1	1.00	53	53	0												
2																
	2.50				NI 40 70		2.5	SPT (C) 100/55mm (25/40mm-**100/55mm**---)			(4.40)			(4.40)		
3		73	47	0												
4	4.00															
		87	83	0							4.60					
5	5.50						5.5	SPT (C) 100/5mm (25/15mm-**100/5mm**---)				Moderately strong dark grey SILTSTONE. Weathering; Moderate becoming light with depth. Some occasional slight weakening of the rock on fractures and broen staining occasional seen on the same frcatures. Fractures; Set 1 Subhorizontal to horizontal open smooth and rough planar clean. 5.80-6.00m: Very poor recovery, recovered as angular fine to coarse gravel				
		60	0	0												
6	6.00															
		93	80	15	NI 110 310											
7	7.50															
8		100	90	0												
9	9.00						9	SPT (C) 100/10mm (25/5mm-**100/10mm**---)				9.60-9.71m: Nonintact recovered as angular fine to				
		67	60	7												

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
23/09/2019 17:00	9.00	1.00	4.10
24/09/2019 07:30	9.00	1.00	4.00

Casing

Depth	Diam.
1.00	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed
6.00	4.30	Medium	

Flush

Depth	Type	Returns
0.00 - 16.00	Air Mist	

Remarks: MC450 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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GB	HW	1 Of 2	10

All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH11

Dates : 23/9/19 - 25/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211811.51 E, 216529.07 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
10		67	60	7							(11.40)	coarse gravel. 9.97-10.11m: Vertical fracture stepped and branching rough clean and open. Moderately strong dark grey SILTSTONE. Weathering; Moderate becoming light with depth. Some occasional slight weakening of the rock on fractures and broen staining occasional seen on the same frcatures. Fractures; Set 1 Subhorizontal to horizontal open smooth and rough planar clean. 12.60-12.73m: Nonintact recovered as angular fine to coarse gravel.		(11.40)		
	10.50															
11		33	33	14												
12	12.00						12	SPT (C) 100/4mm (25/0mm-**100/4mm**---)								
		67	67	34	NI 110 310											
13																
	13.50															
14		100	98	71												
15	15.00						15	SPT (C) 100/5mm (25/5mm-**100/5mm**---)								
		80	70	36												
16	16										16.00	Terminated at scheduled depth				
17																
18																
19																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
24/09/2019 17:00	16.00	1.00	10.30
25/09/2019 08:00	16.00	1.00	4.00

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC450 Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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GB	HW	2 Of 2	10	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH11

Dates : 23/9/19 - 25/9/19	Job Number : Q0083	Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211811.51 E 216529.07 N *Co-ordinates to National Grid*

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GB	HW	1 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH11

Dates : 23/9/19 - 25/9/19	Job Number : Q0083	Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211811.51 E 216529.07 N *Co-ordinates to National Grid*

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GB	HW	2 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH11

Dates : 23/9/19 - 25/9/19	Job Number : Q0083	Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211811.51 E 216529.07 N *Co-ordinates to National Grid*

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GB	HW	3 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH11

Dates : 23/9/19 - 25/9/19	Job Number : Q0083	Ground Level : 93.29 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211811.51 E 216529.07 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
GB	HW	4 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH12

Dates : 5/9/19 - 11/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 103.31 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210931.84 E 216077.95 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Brown slightly silty slightly gravelly Clay. (TOPSOIL)		(0.30)		
									0.60 - 0.80	B2	0.30	Very dense grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. (Weathered mudstone)				
1									1.00	ES3						
							1.2	SPT (C) 50/195mm (18-7/20mm-**18-19-13/45mm**-)	1.20 - 1.50	B5	(2.10)			(2.10)		
2							2	SPT (C) 56 (10-15/50mm-**18-18-20**-)	2.00	ES6						
									2.00 - 2.50	B8	2.40	Very dense brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular mudstone. (Weathered mudstone rock)				
							2.7	SPT (C) 50 (16-9/30mm-**19-31**--)								
3							3	SPT (C) 50/30mm (25/40mm-**50/30mm**---)	3.00	ES9	(1.60)			(1.60)		
4	4.00						4	SPT (C) 100/137mm (10-10-**19-81/62mm**--)			4.00	4.00-4.17m: Nonintact recovered as angular fine to coarse gravel				
		73	56	0								Weak dark grey occasionally brown MUDSTONE with thin grey laminations. Weathering; Slight to moderate, some locaised weakening of the rock along fractures and brown staining on most fractures Fractures; Set 1 Subhorizontal open and closed rough planar clean and occasionall filled with clay/dark brown staining. 4.81-4.89m: Nonintact recovered as angular fine to coarse gravel, AZCL 5.63-5.78m: Nonintact recovered as angular fine to coarse gravel, AZCL				
5																
	5.50															
6		65	40	15	NI 90 140											
7	7.00						7	SPT (C) 100/92mm (25/42mm-**47-53/17mm**--)							1	
		100	95	0												

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
05/09/2019 08:00	2.70	1.50	DRY
05/09/2019 16:30	2.70	1.50	DRY
06/09/2019 10:00	3.00	1.50	DRY

Casing

Depth	Diam.
4.00	115.00
4.50	150.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns
0.00 - 14.00	Air Mist	

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH12

Dates : 5/9/19 - 11/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 103.31 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210931.84 E 216077.95 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8	8.00											8.00-8.50m: Nonintact recovered as angular fine to coarse gravel, AZCL				
		85	43	16								Weak dark grey occasionally brown MUDSTONE with thin grey laminations.				
9											(10.00)	Weathering; Slight to moderate, some locaised weakening of the rock along fractures and brown staining on most fractures		(10.00)		
	9.50						9.5	SPT (C) 100/31mm (25/60mm-**100/31mm**---)				Fractures; Set 1 Subhorizontal open and closed rough planar clean and occasionall filled with clay/dark brown staining.				
10		73	33	16								9.50-11.00m: Nonintact recovered as angular fine to coarse gravel, AZCL				
					NI 90 140											
11	11.00											11.00-11.70m: Nonintact recovered as angular fine to coarse clayey gravel, AZCL				
		80	32	0								11.70m: Subhorizontal undulating tight fracture filled with quartz.				
12	12.00											12.00-13.00m: Very poor recovery; recovered as angular to subangular fine to coarse gravel of quartz, AZCL				
		20	0	0												
13	13.00											13.00-14.00m: Very poor recovery; recovered as angular to subangular fine to coarse gravel of quartz and clayey gravel of mudstone, AZCL				
		20	0	0												
14	14										14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
10/09/2019 17:30	11.00	4.00	2.20
11/09/2019 08:00	12.00	4.00	2.20

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
8.50	8.00		

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH12

Dates : 5/9/19 - 11/9/19	Job Number : Q0083	Ground Level : 103.31 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210931.84 E 216077.95 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
PO	AJ	1 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH12

Dates : 5/9/19 - 11/9/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 103.31 m A.O.D.
Level to Ordnance Datum

Coordinates: 210931.84 E
216077.95 N
Co-ordinates to National Grid

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH13

Dates : 5/9/19 - 10/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 101.90 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210909.11 E 216110.98 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.50 0.60 - 0.80	ES1 ES2	(0.35)	Brown slightly silty slightly gravelly Clay. (TOPSOIL)		(0.35)		
											0.35 (0.65)	Grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. (Weathered mudstone)		(0.65)		
1	1.00						1	SPT (C) 50/45mm (25/30mm-**50/45mm**---)	1.00	B3	1.00	Weak grey and brownish grey SILTSTONE. Weathering; Heavy, no intact rosk and waekening of rock thoughout. Brown staining seen throughout. Fractures; Subhorizontal open clean smooth undulating and planar				
		100	0	0	NI 0 0											
2	2.50										(3.26)	2.68-2.87m: Nonintact recovered as angular fine to coarse gravel		(3.26)		
3		100	7	0	NI 20 50											
4	4.00						4	SPT (C) 100/84mm (25/60mm-**42-58/9mm**--)				3.70-4.80m: Nonintact recovered as angular fine to coarse gravel				
		80	11	0	NI 25 60						4.26	Weak and medium strong dark grey SILTSTONE. Weathering; Moderate becoming less with depth. Some occasional slight weakening of the rock on fractures and broken sections, staining occasional seen on the same frcatures. Fractures; Set 1 Subhorizontal to horizontal open smooth and rough planar clean.				
5	5.50															
6		100	18	8	NI 20 45							4.87-4.97m: Nonintact recovered as angular fine to coarse gravel				
	6.80						6.8	SPT (C) 100/90mm (25/31mm-**72-28/15mm**--)				5.07-5.20m: Nonintact recovered as angular fine to coarse gravel				
7		100	27	7								5.34-6.07m: Nonintact recovered as angular fine to coarse gravel				
												6.12-6.30m: Nonintact recovered as angular fine to coarse gravel				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
05/09/2019 10:30	1.00		DRY

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: DANDO 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH13

Dates : 5/9/19 - 10/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 101.90 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210909.11 E 216110.98 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8																
	8.30	100	27	7	NI 80 150							6.59-7.00m: Nonintact recovered as angular fine to coarse gravel. 7.40-7.60m: Nonintact recovered as angular fine to coarse gravel. Weak and medium strong dark grey SILTSTONE. Weathering; Moderate becoming less with depth. Some occasional slight weakening of the rock on fractures and broken sections, staining occasional seen on the same frcatures. Fractures; Set 1 Subhorizontal to horizontal open smooth and rough planar clean. 9.80-10.40m: Nonintact recovered as angular fine to coarse gravel. 11.62-11.72m: Nonintact recovered as angular fine to coarse gravel.				
9		100	39	10							(9.74)			(9.74)		
	9.80				NI 30 180		9.8	SPT (C) 100/31mm (25/17mm-**100/31mm**---)								
10		100	36	32												
11																
	11.30	83	34	23	NI 50 320											
12	12.00						12	SPT (C) 100/18mm (25/14mm-**100/18mm**---)								
		100	49	33												
13																
	13.50	70	14	0	NI 40 110											
14	14						14	SPT (C) 100/16mm (25/18mm-**100/16mm**---)			14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
09/09/2019 17:00	14.00	1.00	1.70
10/09/2019 08:00	14.00	1.00	1.64

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
9.00	9.00	Medium water ingress at 9.0mbgl	

Flush

Depth	Type	Returns

Remarks: DANDO 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH13

Dates : 5/9/19 - 10/9/19	Job Number : Q0083	Ground Level : 101.90 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210909.11 E 216110.98 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH13

Dates : 5/9/19 - 10/9/19	Job Number : Q0083	Ground Level : 101.90 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210909.11 E 216110.98 N *Co-ordinates to National Grid*

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PO	AJ	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH14

Dates : 6/9/19 - 12/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 103.66 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210958.32 E 216115.39 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0									0.30	ES1	(0.30)	Orange Brown slightly silty slightly gravelly sandy Clay. (TOPSOIL)		(0.30)		
									0.50 - 1.00	B2	0.30	Very dense grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. (Weathered mudstone)				
1							1.2	SPT (C) 50 (15-10/50mm-**16-17-17**-)	1.00	ES3	(1.10)			(1.10)		
									1.20 - 1.70	B5	1.40	MUDSTONE, recovered as: Grey brown slightly clayey GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.				
2							2	SPT (C) 50/115mm (20-5/5mm-**30-20/40mm**--)	2.00	ES6	(1.10)			(1.10)		
	2.50										2.50	Weak brown MUDSTONE; Poor recovery, recovered as subangular fine to coarse gravel.				
3		82	47	30	NI 70 300											
	3.50															
4		40	8	0	NI 20 30											
	4.50										(4.30)			(4.30)		
5		0	0	0	NI 0 0											
	5.50						5.5	SPT (C) 100/75mm (15-10-**50-50/0mm**--)								
6		60	40	0	NI 20 30											
	6.50											6.50-6.90m: Nonintact recovered as angular fine to coarse gravel, AZCL				
7		80	62	0	NI 30 50						6.80	7.02-7.20m: Thick brown laminations of Mudstone 7.32-7.40m: Moderately strong grey sandstone bed				
	7.50															
		50	40	0	NI 60 60											

Description on next page

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
2.00	150.00
2.50	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns
0.00 - 14.00	Air Mist	

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH14

Dates : 6/9/19 - 12/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 103.66 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210958.32 E 216115.39 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8																
	8.50	50	40	0	NI 60 60		8.5	SPT (C) 100/61mm (25/17mm-**100/61mm**---)				Moderatly weak grey MUDSTONE. Weathering; Moderate, some localised weakening of the rock and brown staining on fracture suraces. Fractures; Subhorizontal open planar clean				
9	9.50	50	25	0	NI 40 90							9.36-9.69m: Moderately strong grey sandstone laminations				
10	10.50	95	95	42	20 80 130						(7.70)			(7.70)		
11		100	100	23	20 80 220											
12	11.80	100	92	27	20 95 130		11.8	SPT (C) 100/40mm (25/15mm-**100/40mm**---)				11.75-11.90m: Moderately strong grey sandstone laminations 12.55-12.61m: Moderately strong grey sandstone laminations				
13	13.00															
14		93	93	42	30 100 180											
	14.5						14.5	SPT (C) 100/22mm (25/9mm-**100/22mm**---)			14.50	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
12/09/2019 17:00	12.40	2.50	2.80
13/09/2019 08:00	14.00	2.60	2.30

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
8.20	8.00		

Flush

Depth	Type	Returns

Remarks: Dando 2000 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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PO+SW	AJ	2 Of 2	8

All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH14

Dates : 6/9/19 - 12/9/19	Job Number : Q0083	Ground Level : 103.66 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210958.32 E 216115.39 N *Co-ordinates to National Grid*

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Operator:	Logged By.	Sheet No.	m Per Page	
PO+SW	AJ	1 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH14

Dates : 6/9/19 - 12/9/19	Job Number : Q0083	Ground Level : 103.66 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210958.32 E 216115.39 N *Co-ordinates to National Grid*

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PO+SW	AJ	2 Of 2	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH15

Dates : 23/9/19 - 24/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210746.24 E, 216054.88 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.25)	Dark brown sandy slightly gravelly SILT. Sand is fine to coarse. Gravel is subrounded of sandstone. (TOPSOIL)		(0.25)		
											0.25	Weak to very weak brown and grey MUDSTONE (Heavily Fractured) Generally recoverd as Nonintact with small bands of intact rock. Weathering; Heavy becoming moderate, Some weakening of the localised bedrock and common brown staining throughout. Freactures; Set 1 Generally rock heavily fractured, Subhorizontal to 45 degrees smooth open plannar ans stained brown				
1	1.20															
2		56	56	0	0 0 30											
	2.80						2.8	SPT (C) 100/136mm (10-15/22mm-**29-71/61mm**--)								
3		80	80	0	0 0 60											
	3.80															
4		82	82	0	0 0 0						(7.85)			(7.85)		
	4.80															
5		65	0	0	0 0 0											
	5.80						5.8	SPT (C) 100/107mm (25/41mm-**61-39/32mm**--)								
6		62	50	0	0 10 60											
	6.80															
7		71	70	0	0 0 0							7.80-8.20m: Nonintact				

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water

Casing

Depth	Diam.
1.00	147.00

Groundwater

Struck	Rose To	Behaviour	Sealed
6.70	5.70		

Flush

Depth	Type	Returns
0.00 - 14.30	Air Mist	

Remarks: MC305 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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Operator:	Logged By.	Sheet No.	m Per Page	
RM	HW	1 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH15

Dates : 23/9/19 - 24/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210746.24 E, 216054.88 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8											8.10	recovered as angular fine to coarse gravel, AZCL				
	8.80						8.8	SPT (C) 100 (25/30mm-**100**---)				Weak dark grey MUDSTONE (Heavily Fractured) Weathering; slight some slightly reduced rock strength and brown staining on fractures. Fractures; Subhorizontal open and closed planar smooth with brown staining 8.80-9.30m: Nonintact recovered as angular fine to coarse gravel, AZCL				
9		62	41	0	0 70 90											
	9.80											9.80-10.00m: Nonintact recovered as angular fine to coarse gravel, AZCL				
10		87	83	0	0 35 90							10.70-10.73m: Nonintact recovered as angular fine to coarse gravel, AZCL				
11	11.30						11.3	SPT (C) 100/18mm (25/18mm-**100/18mm**---)			(6.20)	11.30-11.35m: Nonintact recovered as angular fine to coarse gravel, AZCL 11.55-11.63m: Nonintact recovered as angular fine to coarse gravel, AZCL		(6.20)		
12		87	87	0	0 45 99											
	12.80											12.80-13.10m: AZCL (no core) 13.02-13.50m: Vertical open rough stepped clean fracture				
13		67	55	7	0 60 110											
14	14.3						14.3	SPT (C) 100/40mm (25/17mm-**100/40mm**---)			14.30	13.95-14.30m: Nonintact recovered as angular fine to coarse gravel, AZCL Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
23/09/2019 17:00	14.30	2.50	5.70

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed

Flush

Depth	Type	Returns

Remarks: MC305 MC305. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH15

Dates : 23/9/19 - 24/9/19	Job Number : Q0083	Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210746.24 E 216054.88 N *Co-ordinates to National Grid*

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RM	HW	1 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH15

Dates : 23/9/19 - 24/9/19	Job Number : Q0083	Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210746.24 E 216054.88 N *Co-ordinates to National Grid*

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RM	HW	2 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH15

Dates : 23/9/19 - 24/9/19	Job Number : Q0083	Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210746.24 E 216054.88 N *Co-ordinates to National Grid*

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RM	HW	3 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH15

Dates : 23/9/19 - 24/9/19	Job Number : Q0083	Ground Level : 93.55 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210746.24 E 216054.88 N *Co-ordinates to National Grid*

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RM	HW	4 Of 4	2	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH16

Dates : 6/9/19 - 9/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 91.84 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210813.56 E 216012.25 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
0											(0.30)	Orange Brown slightly silty slightly gravelly sandy Clay. (TOPSOIL)		(0.30)		
											0.30					
											(0.70)	Grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. (Weathered mudstone)		(0.70)		
1	1.00	77	15	7	NI 10 60		1	SPT (C) 100/60mm (8-17/35mm-**100/60mm**---)			1.00	1.00-1.52m: Nonitact recovered as angular fine to coarse gravel. AZCL				
2												Weak becoming medium strong dark grey occasionally thinly laminated MUDSTONE. Weathering; Moderate, some localised weakening of rock along fractures with brown staining slightly decreasing with depth. Fractures; Subhorizontal to horizontal open and closed clean, smooth, planar.				
	2.50															
3		45	5	0	NI 30 100											
4	4.00						4	SPT (C) 100/40mm (19-6/0mm-**100/40mm**---)				1.78-1.87m: Nonitact recovered as angular fine to coarse gravel. AZCL				
		73	19	9	NI 70 120							2.40-2.75m: Nonitact recovered as angular fine to coarse gravel. AZCL				
5												2.85-4.34m: Nonitact recovered as angular fine to coarse gravel. AZCL				
	5.50											4.64-4.70m: Nonitact recovered as angular fine to coarse gravel. AZCL				
6		86	31	0	NI 50 100							4.97-5.88m: Nonitact recovered as angular fine gravel.				
7	7.00						7	SPT (C) 100/65mm (25/33mm-**100/65mm**---)				6.04-6.13m: Nonitact recovered as angular fine to coarse gravel. AZCL				
		49	1	0	NI 40 60							6.45-6.50m: Nonitact recovered as angular fine to coarse gravel.				
												6.68-8.92m: Nonitact recovered as angular fine to coarse gravel. AZCL				
											(13.00)			(13.00)		

Hole Progress / Water Obs				Casing		Groundwater				Flush		
Date / Time	H. Depth	C. Depth	Water	Depth	Diam.	Struck	Rose To	Behaviour	Sealed	Depth	Type	Returns

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No. RCEBH16

Dates : 6/9/19 - 9/9/19

Location : RCE

Job Number : Q0083

Engineer : ARUP

Ground Level : 91.84 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210813.56 E 216012.25 N *Co-ordinates to National Grid*

m B.G.L.	Run Details: Core Run	TCR %	SCR %	RQD %	Fractures: Min Avg Max	FI	Insitu Tests: Depth	Test Results	Samples: Depth	Type No. Blows	Strata: Depth (Thick-ness)	Description	Legend	Red. Level A.O.D.	Water	Install/ Backfill
8												Weak becoming medium strong dark grey occasionally thinly laminated MUDSTONE. Weathering; Moderate, some localised weakening of rock along fractures with brown staining slightly decreasing with depth. Fractures; Subhorizontal to horizontal open and closed clean, smooth, planar. 9.65-9.68m: Nonitact recovered as angular fine to coarse gravel. 10.14-10.90m: Nonitact recovered as angular fine to coarse gravel. AZCL				
		49	1	0	NI 40 60											
	8.50															
9		80	5	0	NI 75 90											
	9.50															
10		80	22	10	NI 70 100											
	10.50						10.5	SPT (C) 100/47mm (25/30mm-**100/47mm**---)								
11		76	10	10	NI 80 70							11.14-11.91m: Nonitact recovered as angular fine gravel.				
	11.50															
12		45	10	7	NI 90 100											
13	13.00						13	SPT (C) 100/15mm (25/10mm-**100/15mm**---)				13.00-13.16m: Nonitact recovered as angular fine to medium gravel. 13.42-14.00m: Nonitact recovered as angular fine to coarse gravel. AZCL				
		58	14	0	NI 50 100											
14	14										14.00	Terminated at scheduled depth				
15																

Hole Progress / Water Obs

Date / Time	H. Depth	C. Depth	Water
09/09/2019 07:30	8.50	1.00	5.70

Casing

Depth	Diam.

Groundwater

Struck	Rose To	Behaviour	Sealed
9.50	5.70	Fast	

Flush

Depth	Type	Returns

Remarks: MC450 MC450. Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with installation as instructed by engineer, with steel top hat concreted in.

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GB	AP	2 Of 2	8	All measurements in metres unless otherwise stated

AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH16

Dates : 6/9/19 - 9/9/19	Job Number : Q0083	Ground Level : 91.84 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210813.56 E 216012.25 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Borehole No.
RCEBH16

Dates : 6/9/19 - 9/9/19	Job Number : Q0083	Ground Level : 91.84 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 210813.56 E 216012.25 N *Co-ordinates to National Grid*

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APPENDIX III – ENGINEERING GEOLOGIST'S TRIAL PIT LOGS

KEY TO BOREHOLE AND TRIAL PIT LOGS

m.A.O.D. metres Above Ordnance Datum.

SAMPLE AND TEST TYPES

U	Undisturbed driven tube sample - 102mm diameter, 450mm long.
P	Undisturbed pushed piston sample - 102mm diameter, 1000mm long.
TW	Undisturbed thin walled push in sample - 100mm diameter, 750mm long.
B	Bulk disturbed sample.
BLK	Block Sample
CBR	Heavy duty undisturbed sample - 154 mm diameter (CBR mould).
D	Small disturbed sample.
LB	Large Bulk disturbed sample (for earthworks testing)
C	Core sample
W	Water sample
G	Gas sample
ES	Environmental sample (soil)
j	Jar sample
t	Tub sample
p	Pot sample
s	Small sample
v	Vial sample
S	Standard Penetration Test using split spoon sampler. (See Note).
C	Standard Penetration Test using a solid 60 degree cone. (See Note).

NOTE: Where a single value is quoted this is the N value for 300 mm penetration following a seating drive of 150 mm. Where this full penetration is not achieved the number of blows is quoted for the penetration below the seating drive eg. 63/160 mm.
Where total penetration is less than the seating drive this is indicated by a + and the number of blows for total penetration is quoted eg. +50/75 mm.

HV	Hand Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
V	Borehole Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
FHT/RHT	Falling / Rising Head Permeability Test.

CORE RUN DETAILS

TCR	Total Core Recovery, %
SCR	Solid Core Recovery, %
RQD	Rock Quality Designation, %
FI	Fracture Index. NI - Non intact where > 25 No. per metre length.

WATER COLUMN SYMBOLS

	First water strike, second water strike etc.
	Standing water level after first strike, second strike etc.
	Seepage.

NOTE:
Legend symbols in accordance with BS 5930 (2015)

KEY TO BOREHOLE AND TRIAL PIT LOGS

MATERIAL LEGENDS

Made Ground	Topsoil	Clay
Gravel	Sand	Silt
Peat	Boulders	Cobbles
Chalk	Conglomerate	Volcaniclastic
Asphalt	Void	Mudstone
Siltstone	Sandstone	Limestone
Ironstone	Mudstone / Siltstone	Breccia
Coal	Coral	Bedrock
Shale	Gypsum	Igneous (Coarse Grained)
Igneous (Fine Grained)	Igneous (Medium Grained)	Metamorphic (Coarse Grained)
Metamorphic (Fine Grained)	Metamorphic (Medium Grained)	

INSTALLATION / BACKFILL DETAILS

Arisings	Concrete	Bentonite cement grout
Bentonite seal	Filter	Pea Gravel
Plain pipe	Slotted pipe	Piezometer / Standpipe tip

NOTE:
Legend symbols in accordance with BS 5930 (2015)

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP01

Date : 20/9/19

Location : RCE

Job Number : Q0083

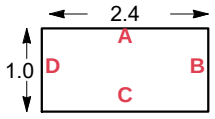
Engineer : ARUP

Ground Level : 75.38 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210357.65 E 216009.71 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.25	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2			0.25	Brown clayey slightly sandy GRAVEL with low cobble content of mudstone. Gravel is angular to sub angular fine to coarse mudstone. (Weathered Mudstone Rock)		75.13	
	0.50 - 1.00	LB3							
1					1.75				
	1.50 -	ES4				...becoming less clayey from 1.4mbgl			
	1.50 - 2.00	B5				... hard dig from 1.8mbgl			
2					2.00	Trial pit terminated at 2.0mbgl for Soakaway test.		73.38	

PLAN



Groundwater: No groundwater encountered

Stability: Sides collapsing from 1.0mbgl

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP01
Date : 20/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 75.38 m A.O.D. *Level to Ordnance Datum* Coordinates: 210357.65 E 216009.71 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

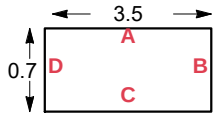
Trial Pit No. RCETP02

Date : 20/9/19 | Job Number : Q0083 | Ground Level : 91.75 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 210573.89 E 216048.57 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.40	Brown slightly sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2							
	0.50 - 1.00	LB3			0.40	Pale brown slightly clayey sandy GRAVEL with low to medium cobble content of calcareous sandstone. Gravel is angular to sub angular fine to coarse calcareous sandstone. Assessed as dense from visual inspection		91.35	
1	1.00 -	ES4							
	1.50 - 2.00	B5			2.80				
2									
	2.50 - 3.00	B6				Difficult dig from 2.8mbgl			
3					3.20	Trial pit terminated at 3.5mbgl, unable to proceed.		88.55	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP02
Date : 20/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 91.75 m A.O.D. *Level to Ordnance Datum* Coordinates: 210573.89 E 216048.57 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP03

Date : 23/9/19

Location : RCE

Job Number : Q0083

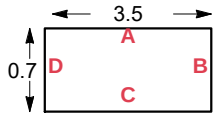
Engineer : ARUP

Ground Level : 94.42 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210653.64 E 216052.76 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.40	Brown slightly sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2							
	0.50 - 1.00	LB3			0.40	Firm orange brown slightly sandy slightly gravelly CLAY.		94.02	
1	1.00 -	ES4			1.00				
	1.50 - 2.00	LB5			1.40	Firm grey slightly sandy gravelly CLAY with low cobble content of sandstone.		93.02	
					0.60				
2					2.00	Pale brown slightly clayey sandy GRAVEL with medium to high cobble content of calcareous sandstone. Gravel is angular to sub angular fine to coarse calcareous sandstone. Assessed as dense from visual inspection		92.42	
	2.50 - 3.00	LB6			1.30				
3					3.30	Trial pit terminated at 3.3mbgl unable to proceed.		91.12	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP03
Date : 23/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 94.42 m A.O.D. *Level to Ordnance Datum* Coordinates: 210653.64 E 216052.76 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP04

Date : 23/9/19

Location : RCE

Job Number : Q0083

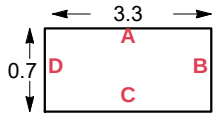
Engineer : ARUP

Ground Level : 94.73 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210719.07 E 216054.98 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
					0.25	Brown slightly sandy slightly gravelly CLAY. (TOPSOIL)			
	0.20 -	D1							
	0.30 -	ES2			0.25	Pale brown grey slightly sandy gravelly CLAY. Gravel is angular to sub angular fine to coarse sandstone and mudstone		94.48	
	0.30 - 0.70	LB3			0.45				
					0.70	Brown slightly sandy clayey GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection. (Weathered Mudstone Rock)		94.03	
1	1.00 - 1.50	LB4							
	1.00 -	ES5							
2	2.00 - 2.50	B6			2.50	...with low cobble content of mudstone from 2.0mbgl			
3	3.00 - 3.20	B7				Difficult dig from 3.0mbgl			
					3.20	Trial Pit terminated at 3.2mbgl unable to proceed through rock.		91.53	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP04
Date : 23/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 94.73 m A.O.D. *Level to Ordnance Datum* Coordinates: 210719.07 E 216054.98 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

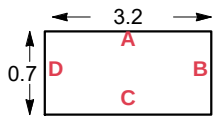
Trial Pit No. RCETP05

Date : 10/9/19 | Job Number : Q0083 | Ground Level : 101.33 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 210893.71 E 216082.71 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Legend	Red. Level A.O.D.	WATER
	0.00 - 0.30	D1			0.35	Brown sandy slightly gravelly CLAY/SILT with many rootletts. (TOPSOIL)			
	0.30 -	ES2			0.35	Orange brown slightly silty slightly sandy gravelly CLAY. Gravel is angular to sub angular fine to coarse mudstone.		100.98	
	0.50 - 0.60	LB3			0.25				
					0.60	Grey brown slightly clayey slightly silty slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection. (weathered Mudstone Rock)		100.73	
1	1.00 -	ES4			0.60				
	1.00 - 1.10	LB5			1.20	MUDSTONE rock, recovered as: Grey brown slightly clayey GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Hard dig from 1.2mbgl		100.13	
2	2.00 - 2.50	LB6			1.95	...with low cobble content of angular mudstone from 2.7mbgl Very difficult dig from 2.7mbgl			
3	3.00 - 3.10	LB7			3.15	Pit terminated at 3.15mbgl unable to proceed into rock with excavator.		98.18	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers			Trial Pit No. RCETP05
Date : 10/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 101.33 m A.O.D. *Level to Ordnance Datum*	
		Coordinates: 210893.71 E 216082.71 N *Co-ordinates to National Grid*	

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP06

Date : 27/9/19

Location : RCE

Job Number : Q0083

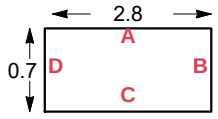
Engineer : ARUP

Ground Level : 102.90 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210992.55 E 216122.25 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
					0.30	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.20 -	D1							
	0.30 -	ES2			0.30	Pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection		102.60	
	0.50 - 1.00	LB4							
1	1.00 -	ES3							
					2.20				
	1.50 - 2.00	B5							
2									
	2.50 - 2.70	B6			2.50	MUDSTONE ROCK - recovered as: Grey brown slightly clayey slightly sandy GRAVEL with low cobble content of mudstone. Gravel is angular fine to coarse mudstone.		100.40	
					0.20				
					2.70	Hard dig from 2.5mbgl Trial pit terminated at 2.7mbgl, unable to proceed.		100.20	

PLAN



Groundwater: Seepage at 2.5mbgl

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP06
Date : 27/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 102.90 m A.O.D. *Level to Ordnance Datum* Coordinates: 210992.55 E 216122.25 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP07

Date : 27/9/19

Location : RCE

Job Number : Q0083

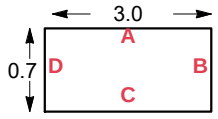
Engineer : ARUP

Ground Level : 96.12 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211051.34 E, 216163.70 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.25	Brown sandy slightly gravelly CLAY with many roots. (TOPSOIL)			
	0.30 -	ES2			0.25	Orange brown gravelly sandy CLAY with many rootletts.		95.87	
	0.30 - 0.50	B3			0.15				
					0.40	Grey brown clayey slightly sandy GRAVEL with low cobble content of mudstone. Gravel is sub angular to sub rounded fine to coarse mudstone. Assessed as dense from visual inspection		95.72	1
1	1.00 -	ES4			1.20				
	1.00 - 1.50	LB5							
					1.60	Grey slightly clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection		94.52	1
2	2.00 - 2.50	LB6				...with low cobble content of mudstone from 2.0mbgl			
					1.10				
					2.70	Trial pit terminated at 2.7mbgl, pit belling out as sides collapsing.		93.42	

PLAN



Groundwater: Fast water strike at 1.6mbgl rising to 0.90m

Stability: Sides collapsing from 1.6mbgl

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP07
Date : 27/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 96.12 m A.O.D. *Level to Ordnance Datum* Coordinates: 211051.34 E 216163.70 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP08

Date : 30/9/19

Location : RCE

Job Number : Q0083

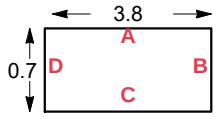
Engineer : ARUP

Ground Level : 89.57 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211178.32 E 216263.01 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.20	Brown slightly sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2			0.20	Mottled pale brown grey sandy slightly gravelly CLAY.		89.37	
	0.50 - 1.00	LB3			1.00				
1					1.20	Brown clayey slightly sandy GRAVEL. Gravel is angular to sub round fine to coarse mudstone and sandstone. Assessed as loose from visual inspection		88.37	
	1.40 -	ES4							
	1.50 - 2.00	LB5							
2					1.70				
	2.50 - 2.90	B6							
3					2.90	Orange slightly clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse sandstone and mudstone. Assessed as dense from visual inspection		86.67	
	3.50 - 4.00	LB7			1.10				
4					4.00	Trial pit terminated at 4.0mbgl at scheduled depth.		85.57	

PLAN



Groundwater: Many seepages from 1.2 to 2.9mbgl

Stability: Sides collapsing from 1.2 - 3.0mbgl

Shoring: None

Remarks : Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No. RCETP08
Client : Welsh Ministers		
Date : 30/9/19	Job Number : Q0083	Ground Level : 89.57 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211178.32 E 216263.01 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP09

Date : 30/9/19

Location : RCE

Job Number : Q0083

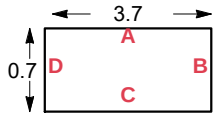
Engineer : ARUP

Ground Level : 87.17 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211274.54 E 216345.76 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.25	Brown slightly sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2			0.25	Pale orange brown slightly gravelly slightly sandy CLAY.		86.92	
	0.50 - 1.00	LB3			0.95				
1					1.20	Orange brown gravelly sandy CLAY with low cobble content of mudstone and sandstone. Gravel is angular to sub rounded fine to coarse mudstone and sandstone.		85.97	
	1.50 -	ES4							
	1.50 - 2.00	LB5			1.10				
2					2.30	Orange brown clayey slightly sandy GRAVEL with low cobble content mudstone and sandstone. Gravel is angular to sub rounded fine to coarse mudstone, sandstone and rare quartz. Assessed as dense from visual inspection.		84.87	
	2.50 - 3.00	LB6							
3					1.70				
	3.50 - 4.00	B7							
4					4.00	Trial pit terminated at 4.0mbgl at scheduled depth.		83.17	

PLAN



Groundwater: Seepage at 0.25mbgl, Slow water ingress at 2.3mbgl

Stability: Sides collapsing from 1.2 - 3.0mbgl

Shoring: None

Remarks : Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP09
Date : 30/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 87.17 m A.O.D. *Level to Ordnance Datum* Coordinates: 211274.54 E 216345.76 N *Co-ordinates to National Grid*

Quantum Geotech	Plas Newydd SA4 0FQ Tel: 01554744880 Fax: email:	Operator: BP	Logged By. A Jones	Sheet No. 2 Of 2	m Per Page	All measurements in metres unless otherwise stated	AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP10

Date : 1/10/19

Location : RCE

Job Number : Q0083

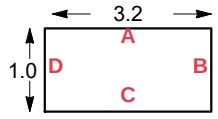
Engineer : ARUP

Ground Level : 84.56 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211364.72 E 216402.22 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.20 - 0.30 -	D1 ES2			0.40	Dark grey brown slightly sandy slightly gravelly slightly organic CLAY. (TOPSOIL)			
	0.50 - 1.00	LB3			0.40	Soft mottled orange grey silty sandy slightly gravelly CLAY.		84.16	
	0.90 -	ES4			0.60				
1					1.00	Orange slightly clayey sandy GRAVEL. Gravel is angular to sub rounded fine to coarse mudstone. Assessed as loose from visual inspection		83.56	
	1.50 - 2.00	LB6							
2					2.00	with low cobble content of mudstone from 2.1mbgl			
	2.50 - 3.00	B5							
3					3.00	Trial pit terminated at 3.0mbgl, sides collapsing and pit belling out.		81.56	

PLAN



Groundwater: Seepage at 0.4mbgl

Stability: Sides collapsing @2.0mbgl from 1.0mbgl

Shoring: None

Remarks : Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No.
Client : Welsh Ministers		RCETP10
Date : 1/10/19	Job Number : Q0083	Ground Level : 84.56 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211364.72 E 216402.22 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

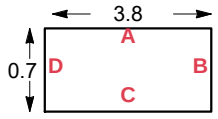
Trial Pit No. RCETP11

Date : 18/9/19 | Job Number : Q0083 | Ground Level : 79.67 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 211503.10 E 216458.26 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.00 - 0.10	D1			0.20	Brown slightly silty sandy organic CLAY. (TOPSOIL)			
	0.30 -	ES2			0.20	Pale mottled orange grey brown slightly sandy slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse mudstone and sandstone.		79.47	
	0.50 - 1.00	LB3			0.80				
1					1.00	Grey brown slightly clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		78.67	
	1.50 -	ES4							
	1.50 - 2.00	LB5			1.10				
2					2.10	Blue grey slightly clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection. (Weathered Mudstone Rock)		77.57	
	2.50 - 3.00	LB6							
3					2.10				
	3.50 - 4.00	B7							
4						Hard dig from 4.0mbgl			
					4.20	Trial pit terminated below scheduled depth, at 4.2mbgl		75.47	

PLAN



Groundwater: Slow water ingress at 3.0mbgl

Stability: Sides collapsing from 3.0mbgl

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No.
Client : Welsh Ministers		RCETP11
Date : 18/9/19	Job Number : Q0083	Ground Level : 79.67 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211503.10 E 216458.26 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP12

Date : 18/9/19

Location : RCE

Job Number : Q0083

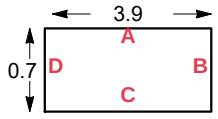
Engineer : ARUP

Ground Level : 79.43 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211529.82 E 216432.08 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
					0.10	Turf with reeds over brown slightly silty sandy organic CLAY. (TOPSOIL)			
	0.10 - 0.20	D1			0.10	Dark grey slightly sandy slightly gravelly organic CLAY with peat.		79.33	
	0.30 -	ES2			0.10	Pale mottled orange grey brown slightly sandy slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse mudstone and sandstone.		79.23	
	0.50 - 1.00	LB3			0.20				
1					1.00				
	1.10 - 1.20	LB4							
	1.30 -	ES5			1.20	Orange brown clayey slightly sandy GRAVEL with low cobble content of mudstone. Gravel is angular to sub angular fine to coarse mudstone. Assessed as loose from visual inspection		78.23	≈
	1.50 - 2.00	LB6							
2					1.80				
	2.50 - 3.00	B7							
3	3.00 - 3.50	LB8			3.00	Dark grey black slightly sandy gravelly CLAY with low cobble content of mudstone. Gravel is angular to sub angular fine to coarse mudstone.		76.43	
					0.50				
					3.50	Trial pit terminated at 3.5mbgl on engineers instruction for soakaway test.		75.93	

PLAN



Groundwater: Seepages at 2.7mbgl

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers			Trial Pit No. RCETP12
Date : 18/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 79.43 m A.O.D. *Level to Ordnance Datum*	
		Coordinates: 211529.82 E 216432.08 N *Co-ordinates to National Grid*	

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCESA12

Date : 19/9/19

Location : RCE

Job Number : Q0083

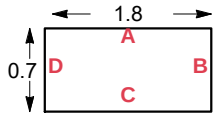
Engineer : ARUP

Ground Level : 78.74 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211585.06 E 216434.87 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 - 0.20	D1			0.05 0.05 0.30	Turf with reeds over brown slightly silty sandy organic CLAY. (TOPSOIL) Dark grey slightly sandy slightly gravelly organic CLAY with peat.		78.69	
	0.50 - 1.00	LB2			0.35	Pale mottled orange grey brown slightly sandy slightly gravelly CLAY. Gravel is angular to sub angular fine to coarse mudstone and sandstone.		78.39	
1					1.25				
					1.60	Trial pit terminated at 1.6mbgl on engineers instruction for soakaway test.		77.14	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14tonne tracked 360

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No. RCESA12
Client : Welsh Ministers		
Date : 19/9/19	Job Number : Q0083	Ground Level : 78.74 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211585.06 E 216434.87 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP13

Date : 26/9/19

Location : RCE

Job Number : Q0083

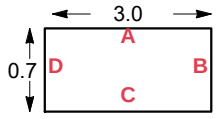
Engineer : ARUP

Ground Level : 84.02 m A.O.D. *Level to Ordnance Datum*

Coordinates: 211689.79 E 216487.20 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D2			0.30	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES1			0.30	Pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		83.72	
	0.50 - 1.00	LB4			1.10				
1					1.40	Dark grey slightly silty slightly sandy GRAVEL. Gravel is angular fine to coarse mudstone. Assessed as dense from visual inspection. (Weathered Mudstone Rock)		82.62	
	1.50 -	ES3							
	1.50 - 2.00	LB5							
2					1.30				
	2.50 - 2.70	B6							
					2.70	Trial pit terminated at 2.7mbgl unable to proceed.		81.32	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP13
Date : 26/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 84.02 m A.O.D. *Level to Ordnance Datum* Coordinates: 211689.79 E 216487.20 N *Co-ordinates to National Grid*

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

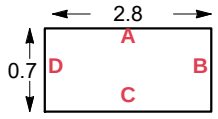
Trial Pit No. RCETP14

Date : 26/9/19 | Job Number : Q0083 | Ground Level : 92.53 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 211762.41 E 216513.46 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.20	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2			0.20	Orange brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as loose from visual inspection		92.33	
	0.50 - 0.70	LB3			0.50				
1	1.00 - 1.50	LB4			0.70	Pale brown slightly clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection. (Weathered Mudstone Rock)		91.83	
	1.50 -	ES5			1.50				
2									
	2.20 - 2.50	B6			2.20	MUDSTONE ROCK - Recovered as: Pale brown slightly silty GRAVEL with low cobble content of mudstone. Gravel is angular fine to coarse mudstone.		90.33	≈
					0.30	...hard dig from 2.2mbgl			
					2.50	Trial pit terminated at 2.5mbgl unable to proceed		90.03	

PLAN



Groundwater: Seepage at 2.2mbgl

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No.
Client : Welsh Ministers		RCETP14
Date : 26/9/19	Job Number : Q0083	Ground Level : 92.53 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211762.41 E 216513.46 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

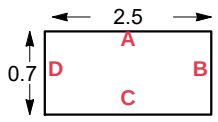
Trial Pit No. RCETP15

Date : 26/9/19 | Job Number : Q0083 | Ground Level : 93.11 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 211852.90 E 216548.15 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Legend	Red. Level A.O.D.	WATER
	0.10 -	D1			0.40	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2							
	0.50 - 1.00	LB4			0.40	Pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection		92.71	
1	1.00 -	ES3			0.65				
					1.05	MUDSTONE ROCK recovered as: Grey brown slightly silty GRAVEL with low cobble content of mudstone. Gravel is angular fine to coarse mudstone.		92.06	
	1.50 - 1.70	LB5			0.65	Very hard dig from 1.5mbgl			
					1.70	Trial pit terminated at 1.7mbgl unable to proceed		91.41	

PLAN



Groundwater: Seepage at 1.05mbgl

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement		Trial Pit No. RCETP15
Client : Welsh Ministers		
Date : 26/9/19	Job Number : Q0083	Ground Level : 93.11 m A.O.D. *Level to Ordnance Datum*
Location : RCE	Engineer : ARUP	Coordinates: 211852.90 E 216548.15 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Trial Pit No. RCETP18

Date : 27/9/19

Location : RCE

Job Number : Q0083

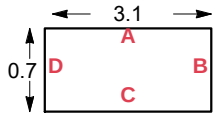
Engineer : ARUP

Ground Level : 102.95 m A.O.D. *Level to Ordnance Datum*

Coordinates: 210931.73 E 216101.61 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thickness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.10 -	D1			0.25	Brown sandy slightly gravelly CLAY. (TOPSOIL)			
	0.30 -	ES2			0.25	Orange brown clayey slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection		102.70	
	0.50 - 0.90	LB3			0.70				
1	1.00 -	ES4			0.95	MUDSTONE ROCK - recovered as: Grey brow slightly clayey slightly sandy GRAVEL with low cobble content of mudstone. Gravel is angular fine to coarse mudstone. Hard dig from 1.2mbgl		102.00	
	1.50 - 2.00	LB5			1.15				
2					2.10	Trial pit terminated at 2.1mbgl		100.85	

PLAN



Groundwater: No groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP18
Date : 27/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 102.95 m A.O.D. *Level to Ordnance Datum* Coordinates: 210931.73 E 216101.61 N *Co-ordinates to National Grid*

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

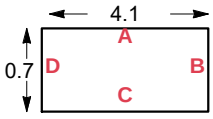
Trial Pit No. RCETP19

Date : 10/9/19 | Job Number : Q0083 | Ground Level : 102.14 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 210893.20 E 216045.17 N *Co-ordinates to National Grid*

m B.G.L.	Samples Depth	Samples Type No.	Tests Depth	Tests Test Results	Strata Depth (Thick-ness)	Strata Description	Strata Legend	Strata Red. Level A.O.D.	WATER
	0.00 - 0.30	D1			0.35	Brown sandy slightly gravelly CLAY/SILT with rare fine coal and many rootletts. (TOPSOIL)			
	0.30 -	ES2			0.35 0.40	Grey brown clayey slightly silty slightly sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone. Assessed as dense from visual inspection. (weathered Mudstone Rock)		101.79	
	0.60 - 0.70	LB4							
	0.70 -	ES3			0.75	MUDSTONE rock, recovered as: Grey brown slightly clayey GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		101.39	
1	1.00 - 1.50	LB5				Hard dig from 1.0mbgl			
					1.95	...with low cobble content of angular mudstone from 2.7mbgl			
2	2.00 - 2.50	LB6				Very difficult dig from 2.0 mbgl			
					2.70	Pit terminated at 2.7mbgl unable to proceed into rock with excavator.		99.44	

PLAN



Groundwater: No Groundwater encountered

Stability: Stable

Shoring: None

Remarks : Hole marked out with handheld GPS. CAT scanned and service plans consulted. Hole backfilled on completion with arisings compacted in layers with topsoil replaced at surface.

Equipment Used: 14 tonne tracked 360 excavator

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement Client : Welsh Ministers		Trial Pit No. RCETP19
Date : 10/9/19 Location : RCE	Job Number : Q0083 Engineer : ARUP	Ground Level : 102.14 m A.O.D. *Level to Ordnance Datum* Coordinates: 210893.20 E 216045.17 N *Co-ordinates to National Grid*

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AGS

APPENDIX IV – ENGINEERING GEOLOGIST'S DYNAMIC SAMPLE LOGS

KEY TO BOREHOLE AND TRIAL PIT LOGS

m.A.O.D. metres Above Ordnance Datum.

SAMPLE AND TEST TYPES

U	Undisturbed driven tube sample - 102mm diameter, 450mm long.
P	Undisturbed pushed piston sample - 102mm diameter, 1000mm long.
TW	Undisturbed thin walled push in sample - 100mm diameter, 750mm long.
B	Bulk disturbed sample.
BLK	Block Sample
CBR	Heavy duty undisturbed sample - 154 mm diameter (CBR mould).
D	Small disturbed sample.
LB	Large Bulk disturbed sample (for earthworks testing)
C	Core sample
W	Water sample
G	Gas sample
ES	Environmental sample (soil)
j	Jar sample
t	Tub sample
p	Pot sample
s	Small sample
v	Vial sample
S	Standard Penetration Test using split spoon sampler. (See Note).
C	Standard Penetration Test using a solid 60 degree cone. (See Note).

NOTE: Where a single value is quoted this is the N value for 300 mm penetration following a seating drive of 150 mm. Where this full penetration is not achieved the number of blows is quoted for the penetration below the seating drive eg. 63/160 mm.
Where total penetration is less than the seating drive this is indicated by a + and the number of blows for total penetration is quoted eg. +50/75 mm.

HV	Hand Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
V	Borehole Vane Test. Vane undrained shear strength, c_u, quoted in kPa.
FHT/RHT	Falling / Rising Head Permeability Test.

CORE RUN DETAILS

TCR	Total Core Recovery, %
SCR	Solid Core Recovery, %
RQD	Rock Quality Designation, %
FI	Fracture Index. NI - Non intact where > 25 No. per metre length.

WATER COLUMN SYMBOLS

	First water strike, second water strike etc.
	Standing water level after first strike, second strike etc.
	Seepage.

NOTE:
Legend symbols in accordance with BS 5930 (2015)

KEY TO BOREHOLE AND TRIAL PIT LOGS

MATERIAL LEGENDS

Made Ground	Topsoil	Clay
Gravel	Sand	Silt
Peat	Boulders	Cobbles
Chalk	Conglomerate	Volcaniclastic
Asphalt	Void	Mudstone
Siltstone	Sandstone	Limestone
Ironstone	Mudstone / Siltstone	Breccia
Coal	Coral	Bedrock
Shale	Gypsum	Igneous (Coarse Grained)
Igneous (Fine Grained)	Igneous (Medium Grained)	Metamorphic (Coarse Grained)
Metamorphic (Fine Grained)	Metamorphic (Medium Grained)	

INSTALLATION / BACKFILL DETAILS

Arisings	Concrete	Bentonite cement grout
Bentonite seal	Filter	Pea Gravel
Plain pipe	Slotted pipe	Piezometer / Standpipe tip

NOTE:
Legend symbols in accordance with BS 5930 (2015)

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS01

Date : 15/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 91.20 m A.O.D.
Level to Ordnance Datum

Coordinates: 210801.71 E
216089.72 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
	Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
								Brown slightly gravelly sandy Clay. (TOPSOIL)			
							(0.30)				
							0.30	Light brown clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		90.90	
			98	100							
							(1.10)				
1											
			78	100							
							1.40	Terminated on obstruction		89.80	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS02

Date : 15/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 92.19 m A.O.D.
Level to Ordnance Datum

Coordinates: 210776.45 E
216071.24 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				Water
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	
						(0.30)	Brown slightly gravelly sandy Clay. (TOPSOIL)			
		98	100			0.30 (0.60)	Light brown clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		91.89	
						0.90	Terminated on obstruction		91.29	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS03

Date : 15/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 90.03 m A.O.D.
Level to Ordnance Datum

Coordinates: 210736.94 E
216028.29 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
							Brown slightly gravelly sandy Clay. (TOPSOIL)			
						(0.30)				
		98	100			0.30	Light brown clayey sandy GRAVEL. Gravel is angular to sub angular fine to coarse mudstone.		89.73	
						(0.30)				
						0.60	Terminated on obstruction		89.43	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS04

Date : 15/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 85.02 m A.O.D. *Level to Ordnance Datum*
Coordinates: 210779.84 E 215999.62 N *Co-ordinates to National Grid*

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
							Brown slightly gravelly sandy Clay. (TOPSOIL)			
						(0.30)				
		98	100			0.30	Soft brown sandy CLAY. Sand is fine to coarse		84.72	
						(0.30)				
						0.60	Brown sandy very clayey GRAVEL. Sand is fine to coarse. Gravel is subangular to subrounded fine to coarse of mudstone.		84.42	
						(0.10)				
						0.70	Terminated on obstruction		84.32	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No. RCEDS05

Date : 27/9/19 | Job Number : Q0083 | Ground Level : 92.56 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 210823.32 E 216079.51 N *Co-ordinates to National Grid*

	Samples		Sample Run		Tests		STRATA				
	Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
	0.10 - 0.30	D 1					0.30	Firm brown slightly gravelly sandy CLAY. Sand is fine to medium. Gravel is fine to medium angular sandstone. (TOPSOIL)			
	0.20 -	ES 1					(0.30)				
	0.30 - 1.00	D 2					0.30	Firm brown sandy gravelly CLAY with fossil rootlets. Sand is fine to medium. Gravel is fine to medium angular mudstone and rare sandstone.		92.26	
	0.30 - 0.70	B 3					(0.70)				
	0.60 -	ES 2									
1	1.00 - 1.30	D 3			1.00 - 1.45	SPT (C) 4 (1-0-**1-1-1-1**)	1.00	Loose grey and brown clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone and rare sandstone.		91.56	
							(0.30)				
							1.30	Firm brown gravelly CLAY. Gravel is fine to coarse angular sandstone.		91.26	
	1.50 -	ES 3					(0.60)				
	1.60 - 1.90	D 4									
							1.90	Mottled orange, grey and black angular sandstone COBBLE.		90.66	
							(0.10)				
2	2.00 - 2.10	D 5			2.00 - 2.38	SPT (C) 52/225mm (10-13-**13-15-20-4/0mm**)	2.00	Very stiff greyish brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine angular mudstone and sandstone.		90.56	
							(0.10)				
							2.10	Terminated on obstruction		90.46	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with arisings and bentonite pellets. Terrier DS rig Terrier Dynamic Sample rig, backfilled with bentonite.

No groundwater encountered

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS06a

Date : 16/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 89.61 m A.O.D. *Level to Ordnance Datum*
Coordinates: 211179.89 E 216250.54 N *Co-ordinates to National Grid*

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
							Soft brown sandy CLAY. Sand is fine to medium. (TOPSOIL)			
						(0.30)				
						0.30	Soft brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and occasional sandstone.		89.31	
		98	100			(0.20)				
						0.50	Grey and brown very clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone.		89.11	
						(0.30)				
						0.80	Terminated on obstruction		88.81	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No. RCEDS06b

Date : 16/10/19 | Job Number : Q0083 | Ground Level : 89.32 m A.O.D. *Level to Ordnance Datum*

Location : RCE | Engineer : ARUP | Coordinates: 211185.24 E 216238.51 N *Co-ordinates to National Grid*

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
						(0.20)	Soft brown sandy CLAY. Sand is fine to medium. (TOPSOIL)			
		98	100			0.20 (0.40)	Soft brown clayey sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and occasional sandstone.		89.12	
						0.60 (0.20)	Brown very clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone.		88.72	
						0.80	Terminated on obstruction		88.52	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS07

Date : 16/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 88.95 m A.O.D.
Level to Ordnance Datum

Coordinates: 211204.30 E
216226.88 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
						(0.25)	Soft brown sandy CLAY. Sand is fine to medium. (TOPSOIL)			
		90	100			0.25 (0.45)	Firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and occasional sandstone.		88.70	
						0.70 (0.10)	Brown clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone.		88.25	
						0.80	Terminated on obstruction		88.15	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS08

Date : 16/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 90.98 m A.O.D.
Level to Ordnance Datum

Coordinates: 211116.41 E
216250.79 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
							Soft dark brown sandy CLAY. Sand is fine to medium. (TOPSOIL)			
						(0.30)				
						0.30	Firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and occasional sandstone.		90.68	
		98	100			(0.40)				
						0.70	Grey and brown very clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone.		90.28	
						(0.20)				
						0.90	Terminated on obstruction		90.08	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS09

Date : 1/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 90.30 m A.O.D.
Level to Ordnance Datum

Coordinates: 211145.34 E
216249.59 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
	Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
							(0.30)	Firm brown slightly gravelly sandy CLAY. Sand is fine to medium. Gravel is fine to medium angular sandstone. (TOPSOIL)			
			98	100			0.30 (0.30)	Firm brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and sandstone.		90.00	
1			98	100	1.00 - 1.45	SPT (C) 15 (3-3-**3-4-4-4**)	0.60 (1.40)	Medium dense grey and brown very clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone and occaional sandstone.		89.70	
2							2.00	Collapsing below 1.0m		88.30	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled with arisings and bentonite pellets. Terrier DS rig Terrier Dynamic Sample rig, backfilled with bentonite.

No groundwater encountered

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AGS

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Window Sample No.
RCEDS10

Date : 16/10/19
Location : RCE

Job Number : Q0083
Engineer : ARUP

Ground Level : 88.68 m A.O.D.
Level to Ordnance Datum

Coordinates: 211207.55 E
216213.70 N
Co-ordinates to National Grid

Samples		Sample Run		Tests		STRATA				
Depth	Type No.	Diam. (mm)	Recovery (%)	Depth	SPT & Hand Vane Results	Depth (Thick-ness)	DESCRIPTION	Legend	Red. Level . A.O.D.	Water
						(0.20)	Brown slightly gravelly sandy CLAY. Sand is fine to medium. Gravel is subangular fine to medium of sanstone. (TOPSOIL)			
						0.20			88.48	
						(0.25)	Soft brown sandy gravelly CLAY. Sand is fine to coarse. Gravel is fine to coarse angular mudstone and sandstone.			
		98	100			0.45			88.23	
						(0.45)	Grey and brown very clayey sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse angular mudstone and occaional sandstone.			
						0.90	Terminated on obstruction		87.78	

Remarks: Hole marked out in liasion with the clients engineer. CAT scanned and service plans consulted. Hole backfilled on completion with arisings and bentonite with topsoil replaced at surface. Hand held window sampler, backfilled with bentonite.

No groundwater encountered

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APPENDIX V – SOAKAWAY RESULTS

Contract : A40 RCE

Client : Welsh Ministers

Point Plotted
RCESA12,1

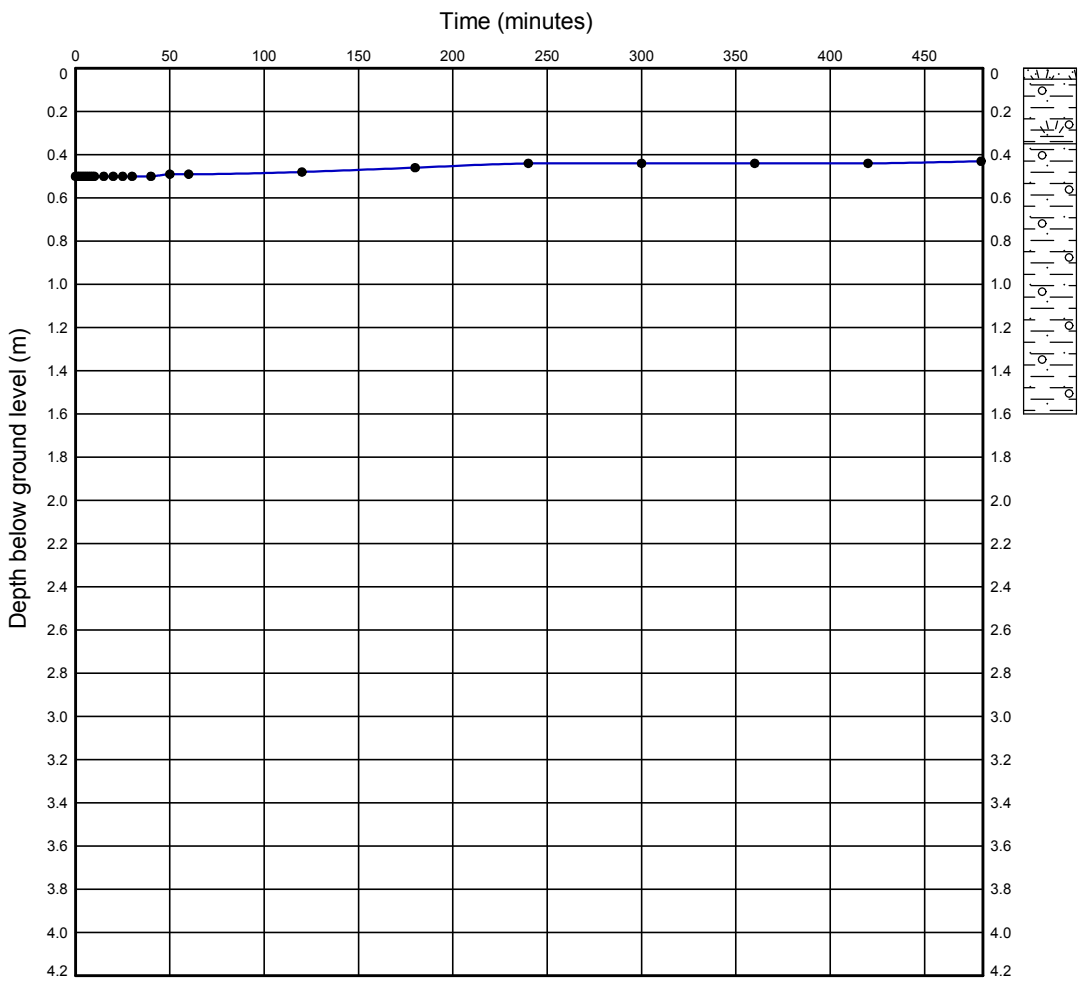
Job Number : Q0083

Engineer : ARUP

SOAKAWAY TEST CALCULATION SHEET

Time (Minutes)	Depth of water from ground level (m)
0.0	0.5
1.0	0.5
2.0	0.5
3.0	0.5
4.0	0.5
5.0	0.5
6.0	0.5
7.0	0.5
8.0	0.5
9.0	0.5
10.0	0.5
15.0	0.5
20.0	0.5
25.0	0.5
30.0	0.5
40.0	0.5
50.0	0.49
60.0	0.49
120.0	0.48
180.0	0.46
240.0	0.44
300.0	0.44
360.0	0.44
420.0	0.44
480.0	0.43

Field Observations from soakaway trial pit



Remarks: Insufficient outflow to calculate permeability

Soakaway test for soil infiltration rate
design method based on BRE Digest 365

Permeability Test on Strata

Trial Pit Depth	1.600 m	V_{p75-25}=	0.693 m^3
Trial Pit Length	1.800 m	a_{p50}=	4.010 m^2
Trial Pit Width	0.700 m	t_{p75-25}=	minutes
Effective Depth	1.100 m		
Outflow Time	mins from 75% to 25% full		

f = m/sec

Quantum

Ty Berwig
Bynea, Llanelli, SA14 9ST
Tel: 01554 744880
Tel:
email: enquiries@quantumgeotech.co.uk

Date of Test: 19/09/2019

All measurements in metres unless otherwise stated

Figure No. 2

Project File: Q0083 AJ (ARWEL JONES'S CONFLICTED COPY 2019-10-21).GPJ

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Point Plotted
RCETP01,1

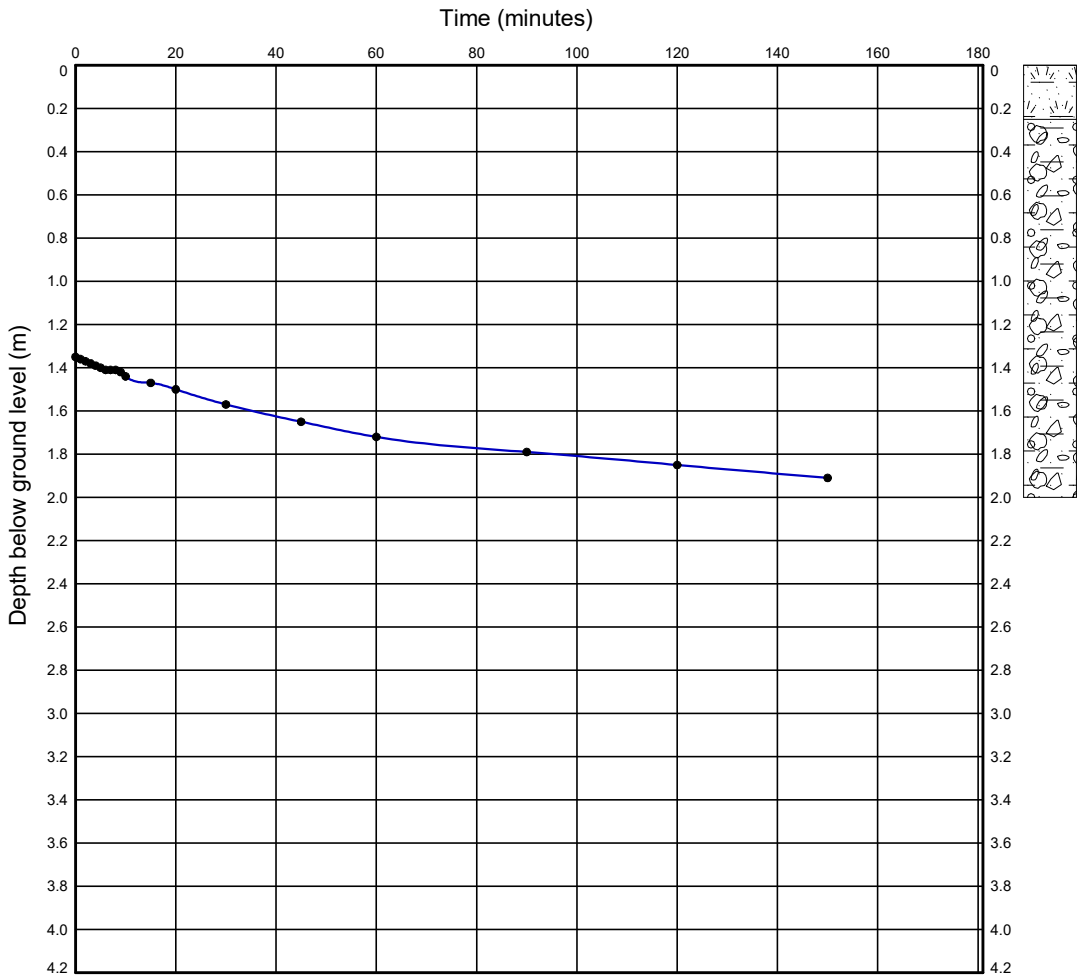
Job Number : Q0083

Engineer : ARUP

SOAKAWAY TEST CALCULATION SHEET

Time (Minutes)	Depth of water from ground level (m)
0.0	1.35
1.0	1.36
2.0	1.37
3.0	1.38
4.0	1.39
5.0	1.4
6.0	1.41
7.0	1.41
8.0	1.41
9.0	1.42
10.0	1.44
15.0	1.47
20.0	1.5
30.0	1.57
45.0	1.65
60.0	1.72
90.0	1.79
120.0	1.85
150.0	1.91

Field Observations from soakaway trial pit



Remarks:

Soakaway test for soil infiltration rate
design method based on BRE Digest 365

Permeability Test on Strata

Trial Pit Depth	2.000 m	V_{p75-25}=	0.780 m^3
Trial Pit Length	2.400 m	a_{p50}=	4.610 m^2
Trial Pit Width	1.000 m	t_{p75-25}=	91.964 minutes
Effective Depth	0.650 m		
Outflow Time	91.964 mins from 75% to 25% full		

f = 3.0664E-5 m/sec

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Plas Newydd
SA4 0FQ
Tel: 01554744880
Tel:
email:

Date of Test: 20/09/2019

All measurements in metres unless otherwise stated

Project File: Q0083 - A40 RCE MASTER GINT.GPJ

Figure No. 1

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Point Plotted
RCETP01,2

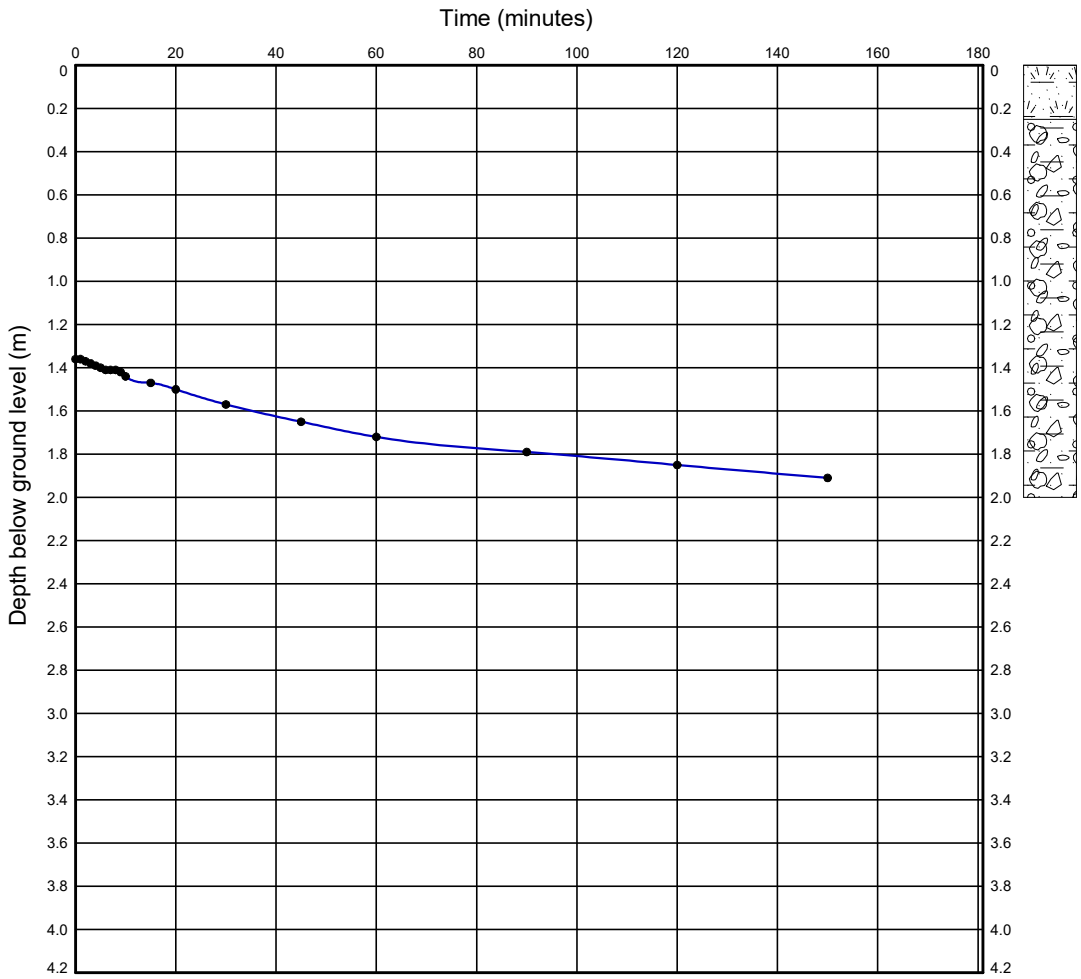
Job Number : Q0083

Engineer : ARUP

SOAKAWAY TEST CALCULATION SHEET

Time (Minutes)	Depth of water from ground level (m)
0.0	1.36
1.0	1.36
2.0	1.37
3.0	1.38
4.0	1.39
5.0	1.4
6.0	1.41
7.0	1.41
8.0	1.41
9.0	1.42
10.0	1.44
15.0	1.47
20.0	1.5
30.0	1.57
45.0	1.65
60.0	1.72
90.0	1.79
120.0	1.85
150.0	1.91

Field Observations from soakaway trial pit



Remarks:

Soakaway test for soil infiltration rate
design method based on BRE Digest 365

Permeability Test on Strata

Trial Pit Depth	2.000 m	V_{p75-25}=	0.780 m^3
Trial Pit Length	2.400 m	a_{p50}=	4.610 m^2
Trial Pit Width	1.000 m	t_{p75-25}=	95.536 minutes
Effective Depth	0.650 m		
Outflow Time	95.536 mins from 75% to 25% full		

f = 2.9517E-5 m/sec

Quantum Geotech
Plas Newydd
SA4 0FQ
Tel: 01554744880
Tel:
email:

Date of Test: 20/09/2019

All measurements in metres unless otherwise stated

Project File: Q0083 - A40 RCE MASTER GINT.GPJ

Figure No. 2

Contract : A40 Penblewin to Redstone Cross Improvement

Client : Welsh Ministers

Point Plotted
RCETP01,3

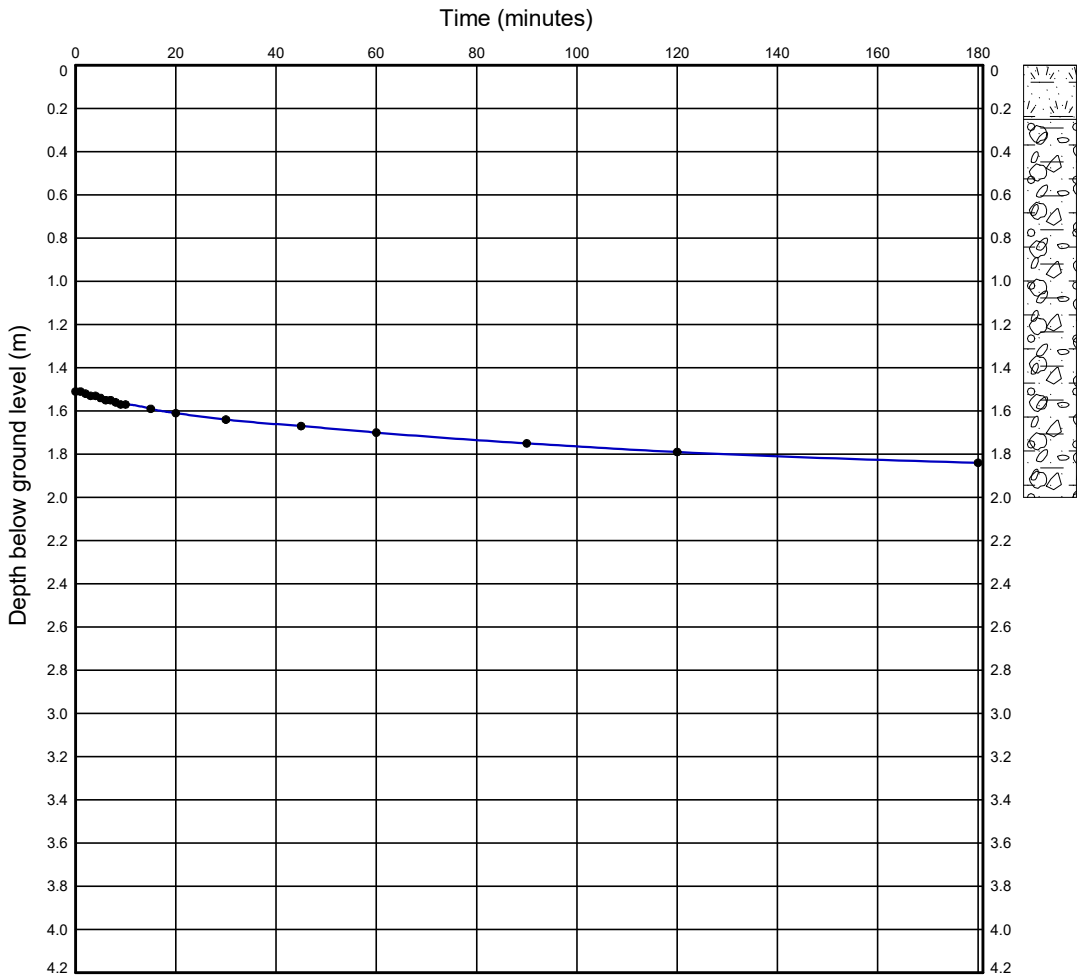
Job Number : Q0083

Engineer : ARUP

SOAKAWAY TEST CALCULATION SHEET

Time (Minutes)	Depth of water from ground level (m)
0.0	1.51
1.0	1.51
2.0	1.52
3.0	1.53
4.0	1.53
5.0	1.54
6.0	1.55
7.0	1.55
8.0	1.56
9.0	1.57
10.0	1.57
15.0	1.59
20.0	1.61
30.0	1.64
45.0	1.67
60.0	1.7
90.0	1.75
120.0	1.79
180.0	1.84

Field Observations from soakaway trial pit



Remarks:

Soakaway test for soil infiltration rate
design method based on BRE Digest 365

Permeability Test on Strata

Trial Pit Depth	2.000 m	V_{p75-25}=	0.780 m^3
Trial Pit Length	2.400 m	a_{p50}=	4.610 m^2
Trial Pit Width	1.000 m	t_{p75-25}=	minutes
Effective Depth	0.650 m		
Outflow Time	mins from 75% to 25% full		

f = m/sec

Quantum Geotech
Plas Newydd
SA4 0FQ
Tel: 01554744880
Tel:
email:

Date of Test: 20/09/2019

All measurements in metres unless otherwise stated

Project File: Q0083 - A40 RCE MASTER GINT.GPJ

Figure No. 3

Contract : A40 RCE & LVP By Pass

Client : Llywodraeth Cymru Welsh Government

Point Plotted
RCETP12,1

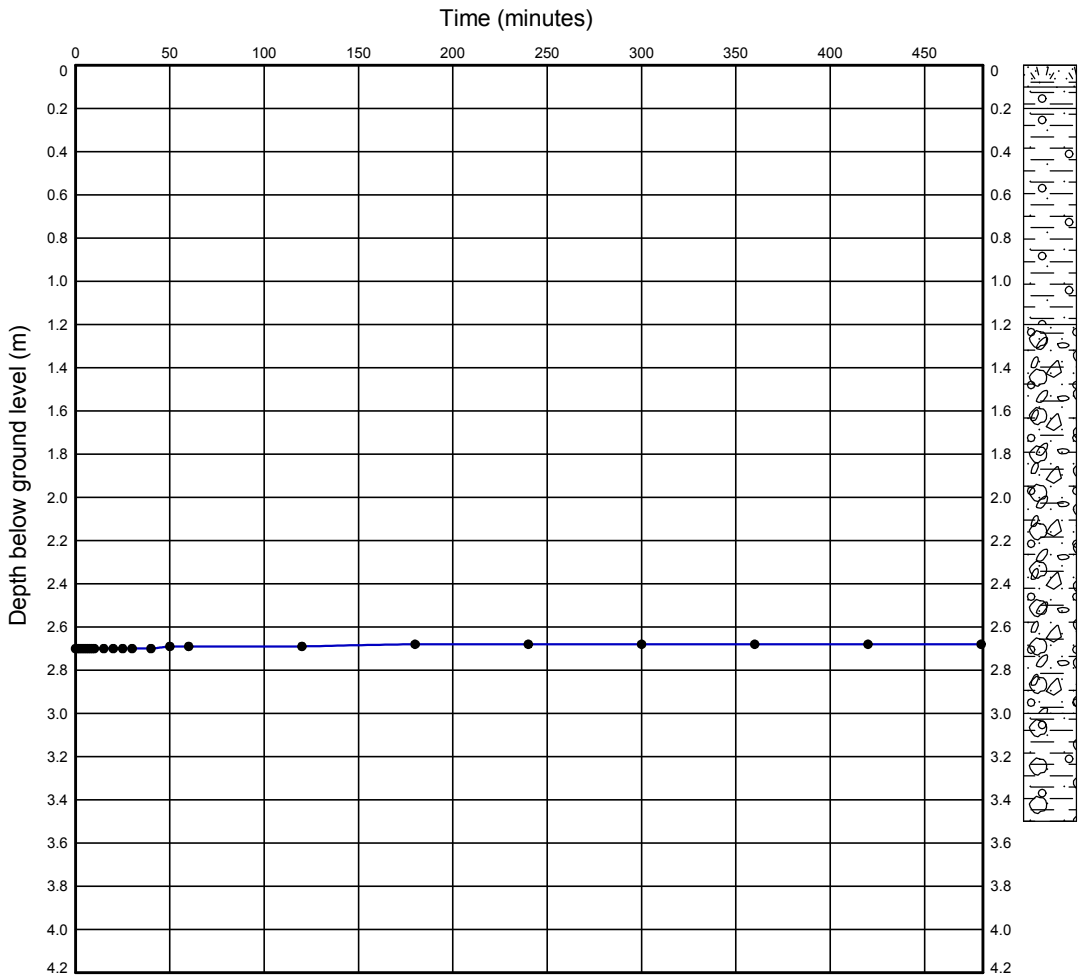
Job Number : Q0083

Engineer : ARUP

SOAKAWAY TEST CALCULATION SHEET

Time (Minutes)	Depth of water from ground level (m)
0.0	2.7
1.0	2.7
2.0	2.7
3.0	2.7
4.0	2.7
5.0	2.7
6.0	2.7
7.0	2.7
8.0	2.7
9.0	2.7
10.0	2.7
15.0	2.7
20.0	2.7
25.0	2.7
30.0	2.7
40.0	2.7
50.0	2.69
60.0	2.69
120.0	2.69
180.0	2.68
240.0	2.68
300.0	2.68
360.0	2.68
420.0	2.68
480.0	2.68

Field Observations from soakaway trial pit



Remarks: Insufficient outflow to calculate permeability

Soakaway test for soil infiltration rate
design method based on BRE Digest 365

Permeability Test on Strata

Trial Pit Depth	3.500 m	V_{p75-25}=	1.092 m^3
Trial Pit Length	3.900 m	a_{p50}=	6.410 m^2
Trial Pit Width	0.700 m	t_{p75-25}=	minutes
Effective Depth	0.800 m		
Outflow Time	mins from 75% to 25% full		

f = m/sec

Quantum

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Tel: 01554 744880
Tel:
email: enquiries@quantumgeotech.co.uk

Date of Test: 18/09/2019

All measurements in metres unless otherwise stated

Figure No. 6

Project File: Q0083 AJ (ARWEL JONES'S CONFLICTED COPY 2019-10-21).GPJ

APPENDIX VI – CBR RESULTS

Quantum Geotech

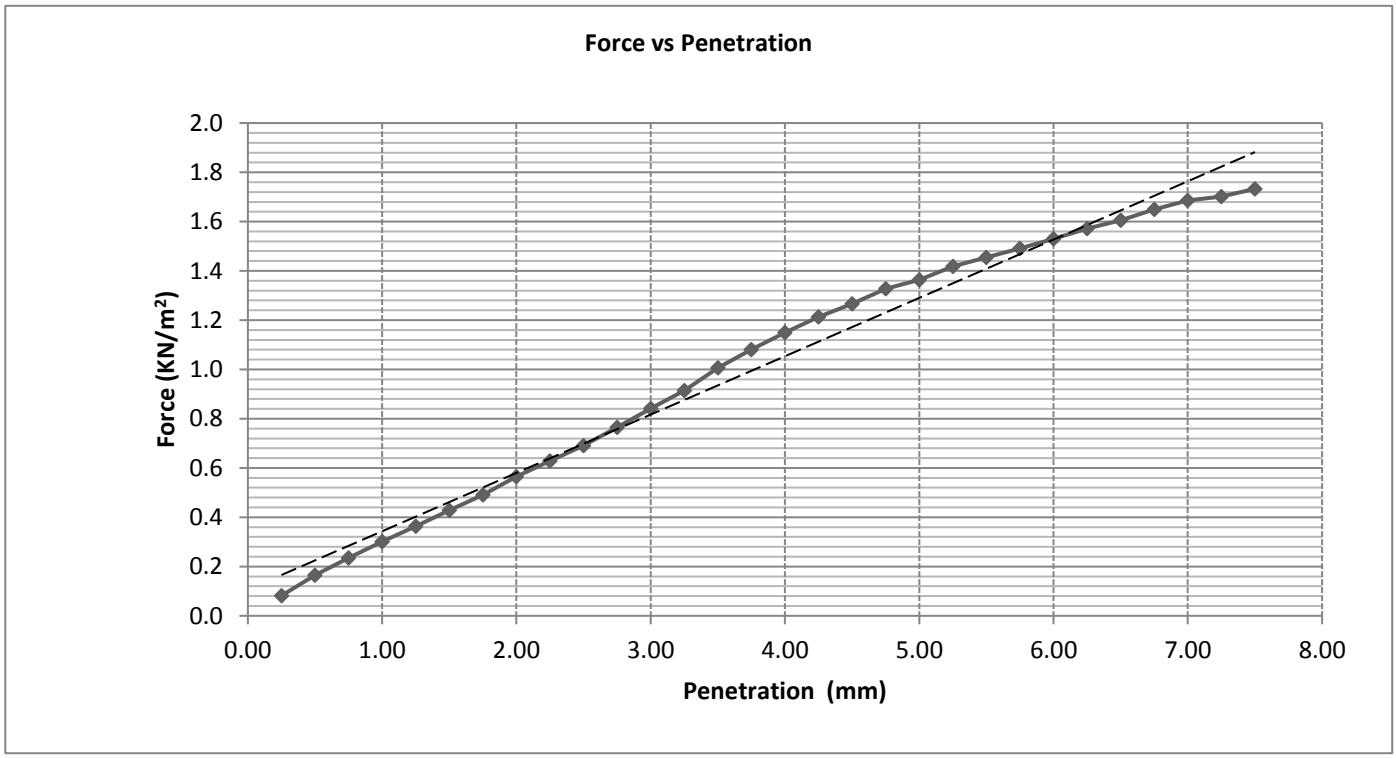
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP01	Lab. Reference:	Q0083.01	Date Tested:	20/09/2019
Sample Location:	RCETP01			Date Received:	20/09/2019
Material Description:	Brown clayey slightly sandy GRAVEL				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.3		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.7	1.4
Standard Force (kN)	13.20	20.00
CBR (%)	5.2	6.8

CBR Value (%)	**6.8**
Moisture Content (%)	**16**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

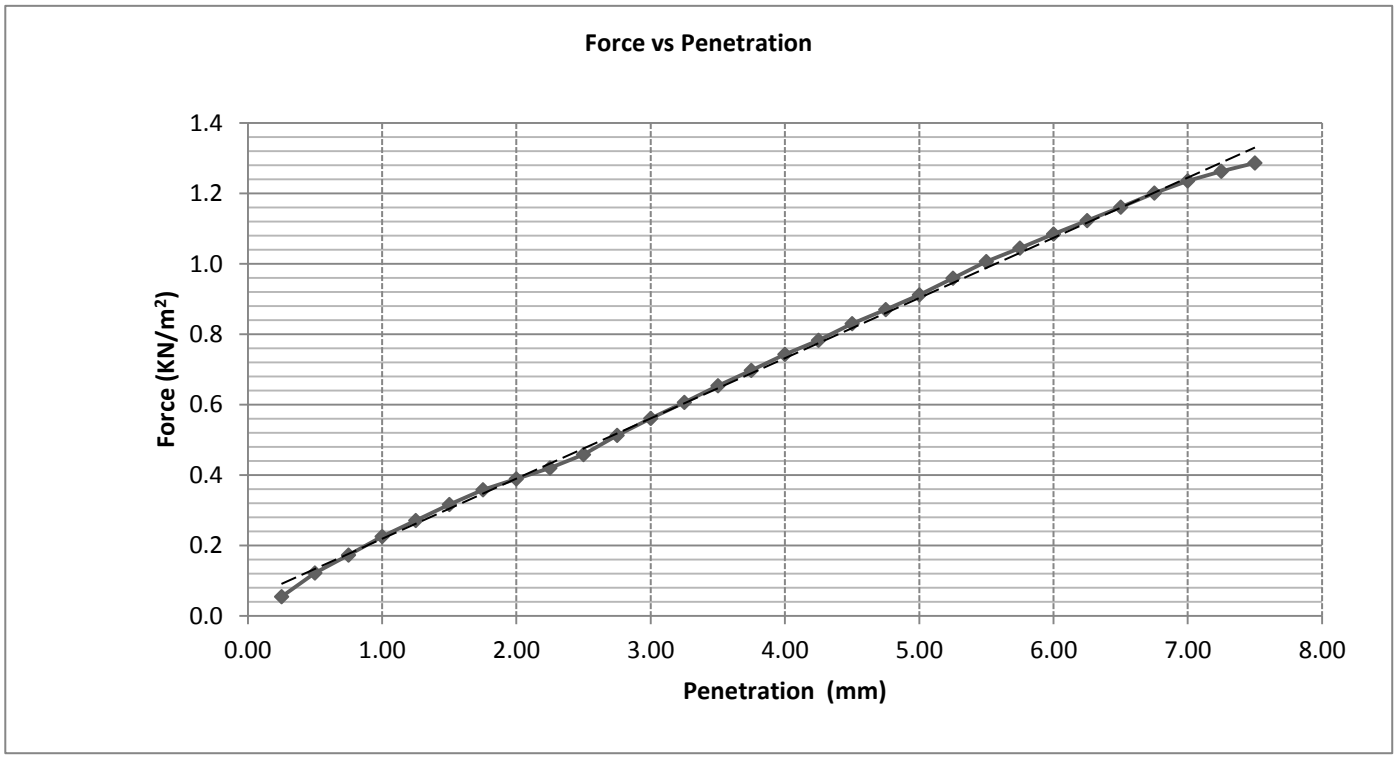
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP02	Lab. Reference:	Q0083.02	Date Tested:	20/09/2019
Sample Location:	RCETP02			Date Received:	20/09/2019
Material Description:	Pale brown slightly clayey sandy GRAVEL				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.3		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.5	0.9
Standard Force (kN)	13.20	20.00
CBR (%)	3.5	4.6

CBR Value (%)	**4.6**
Moisture Content (%)	**20**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

Quantum Geotech

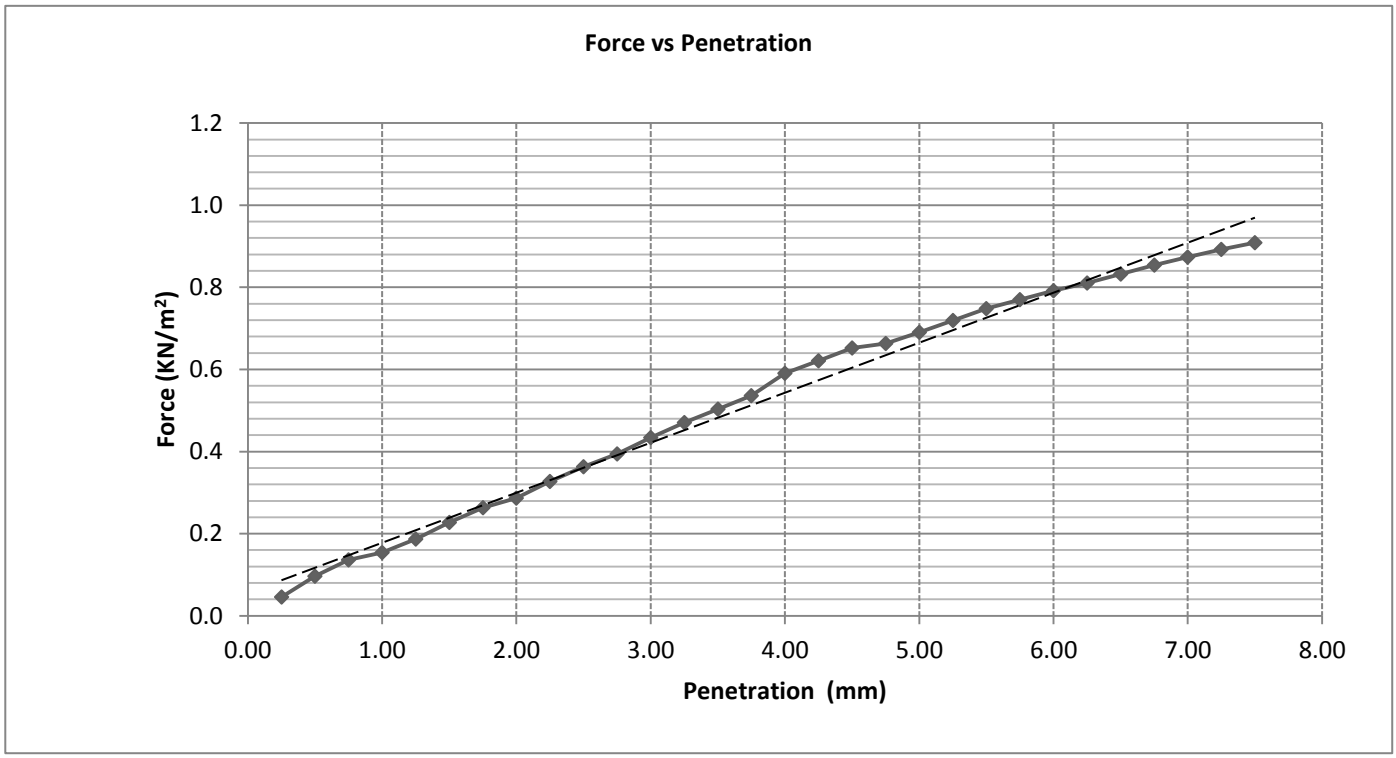
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP05	Lab. Reference:	Q0083.03	Date Tested:	20/09/2019
Sample Location:	RCETP05			Date Received:	20/09/2019
Material Description:	Orange brown slightly silty slightly sandy gravelly CLAY				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.35		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.4	0.7
Standard Force (kN)	13.20	20.00
CBR (%)	2.8	3.5

CBR Value (%)	**3.5**
Moisture Content (%)	**18**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

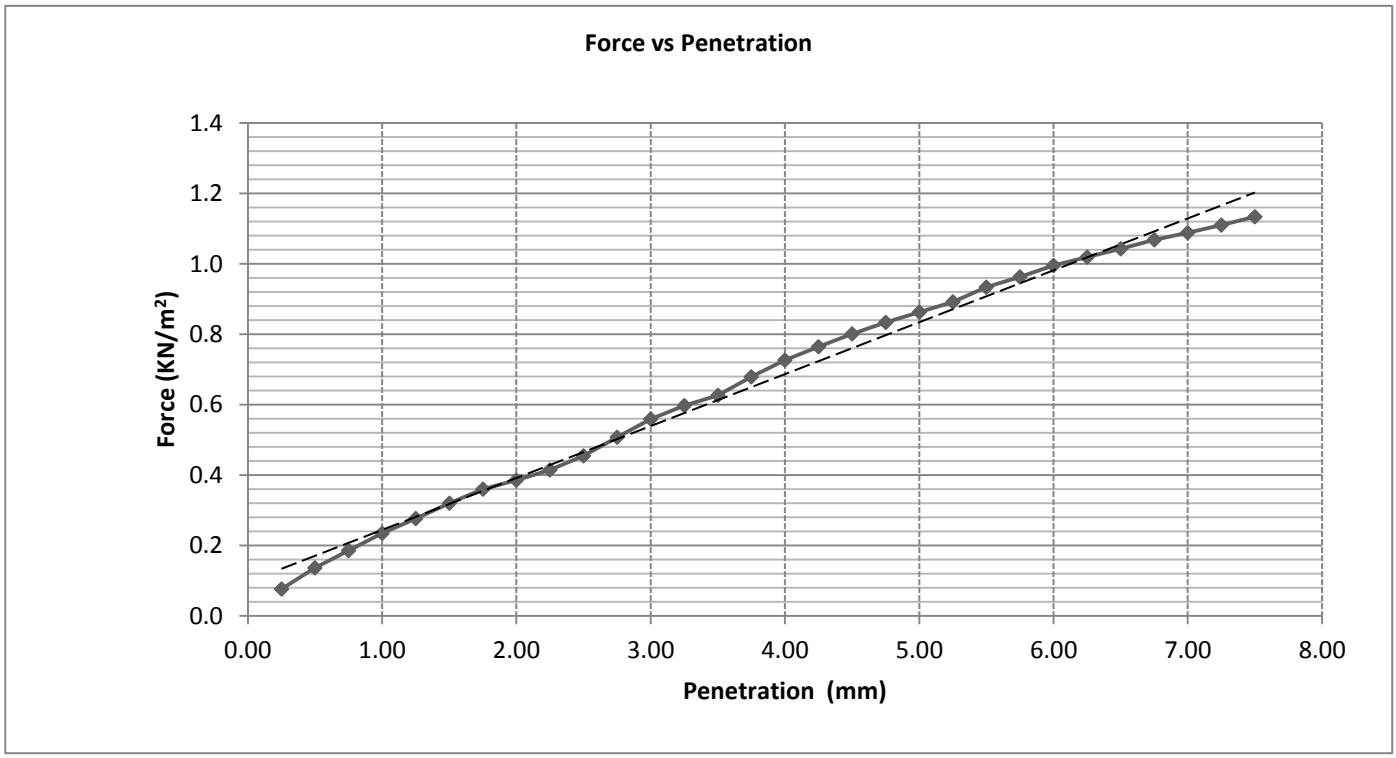
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP06	Lab. Reference:	Q0083.04	Date Tested:	27/09/2019
Sample Location:	RCETP06			Date Received:	27/09/2019
Material Description:	Pale brown clayey slightly sandy GRAVEL				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.3		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.5	0.9
Standard Force (kN)	13.20	20.00
CBR (%)	3.4	4.3

CBR Value (%)	**4.3**
Moisture Content (%)	**14**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

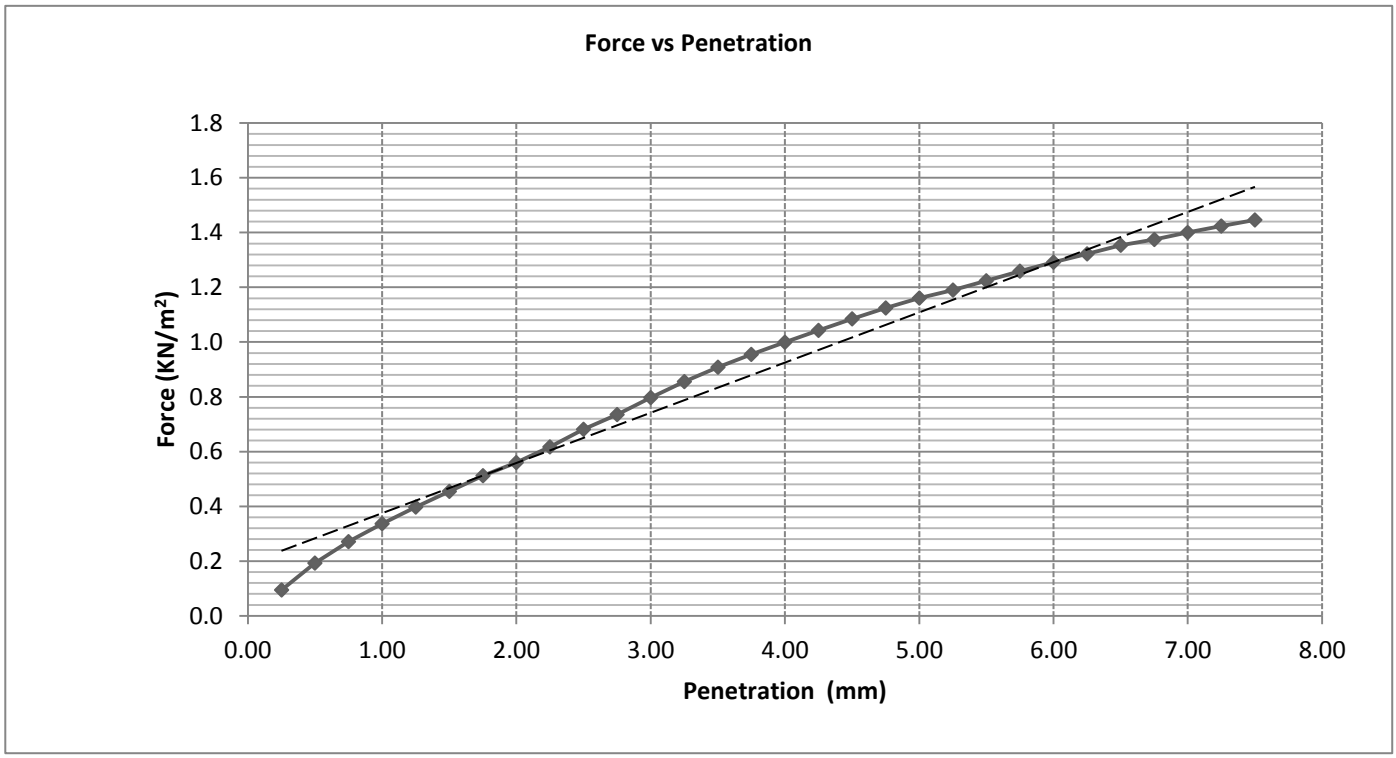
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP13	Lab. Reference:	Q0083.05	Date Tested:	27/09/2019
Sample Location:	RCETP13			Date Received:	27/09/2019
Material Description:	Pale brown clayey slightly sandy GRAVEL				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.3		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.7	1.2
Standard Force (kN)	13.20	20.00
CBR (%)	5.2	5.8

CBR Value (%)	**5.8**
Moisture Content (%)	**16**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

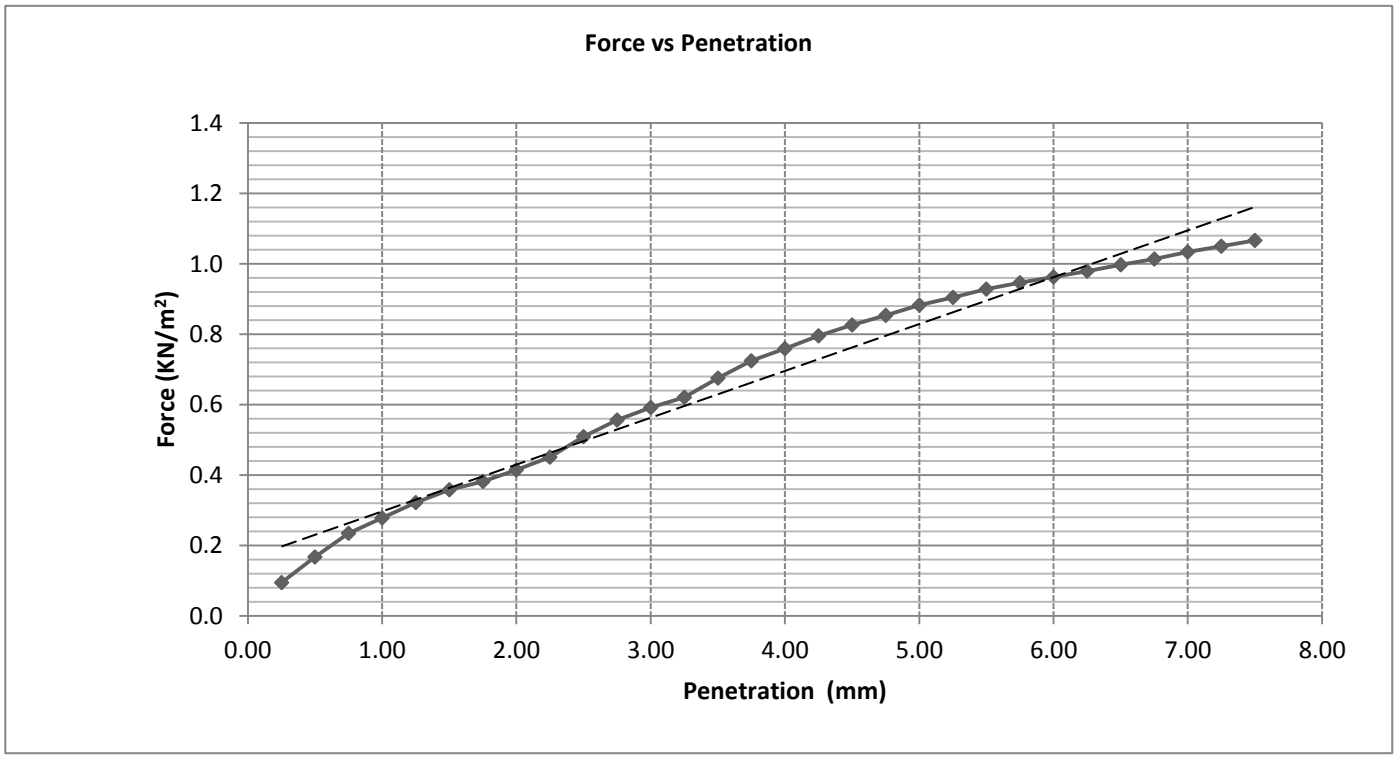
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP18	Lab. Reference:	Q0083.06	Date Tested:	27/09/2019
Sample Location:	RCETP18			Date Received:	27/09/2019
Material Description:	Orange brown clayey slightly sandy GRAVEL				
Supplier:	In Situ		Source:	In Situ	
Depth Below Ground Level:	0.3		Reaction Load:	4 x 4 Vehicle	



Peneration (mm)	2.50	5.00
Force (kN)	0.5	0.9
Standard Force (kN)	13.20	20.00
CBR (%)	3.9	4.4

CBR Value (%)	**4.4**
Moisture Content (%)	**15**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

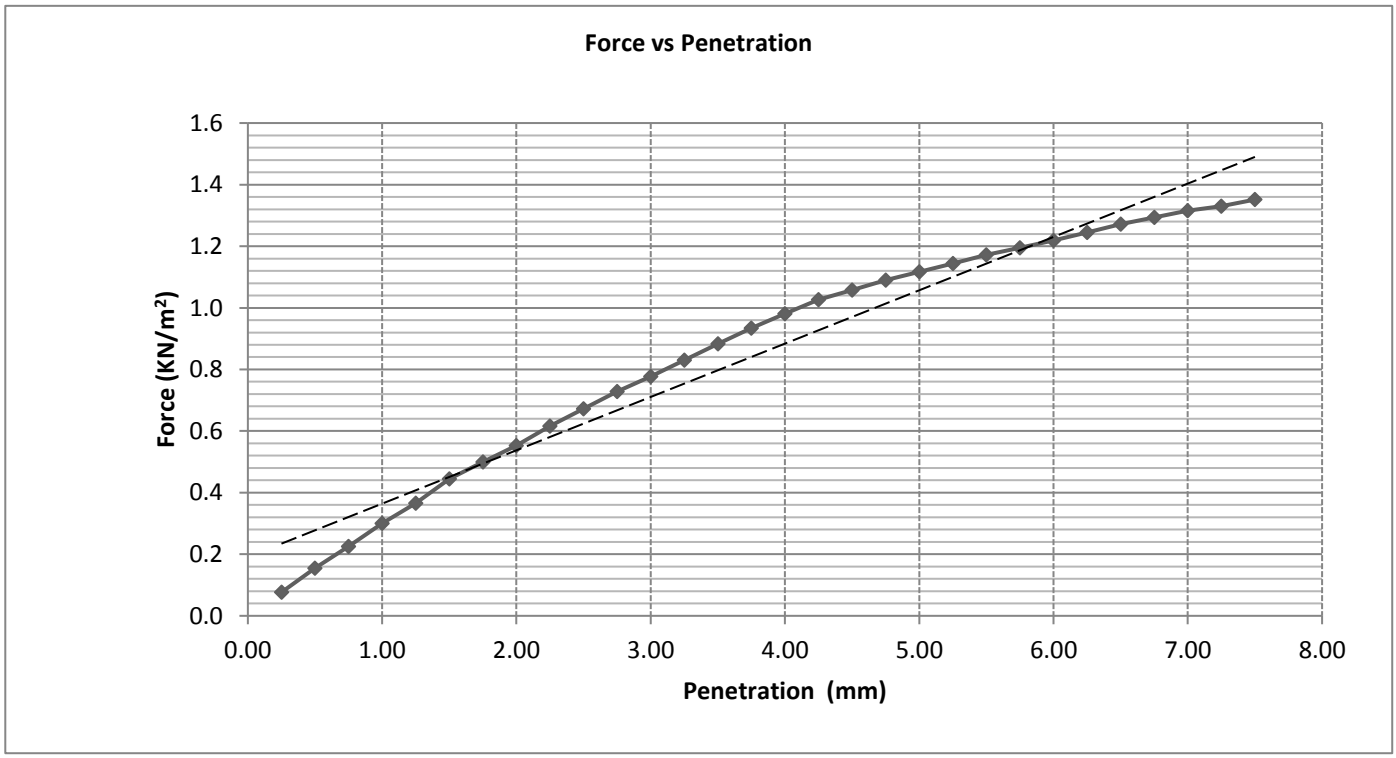
Quantum Geotechnical

Plas Newydd,
Llanedi, Pontardulais,
Swansea, SA4 0FQ
Tel.: 01554 744880

Determination of In Situ CBR to BS 1377: Part 9: 1990: Cl.4.3

Client Name:	Welsh Government		
Client Address:			
Contract Name:	A40 RCE - LVP	**Contract No.:**	Q0083

Site Reference:	RCETP19	Lab. Reference:	Q0083.07	Date Tested:	20/09/2019
Sample Location:	RCETP19			Date Received:	20/09/2019
Material Description:	Grey brown clayey slightly silty slightly sandy GRAVEL				
Supplier:	In Situ	Source:	In Situ		
Depth Below Ground Level:	0.3	Reaction Load:	4 x 4 Vehicle		



Peneration (mm)	2.50	5.00
Force (kN)	0.7	1.1
Standard Force (kN)	13.20	20.00
CBR (%)	5.1	5.6

CBR Value (%)	**5.6**
Moisture Content (%)	**15**

Remarks:

Signed:
Position: Senior Engineering Technician
Dated: 22 October 2019

APPENDIX VII – GEOTECHNICAL LABORATORY TEST RESULTS

Laboratory Report

UKAS TESTING
2788

GSTL
GEO Site & Testing Services Ltd

Contract Number: 46614

Client Ref: **Q0083**
Client PO: **POR000638**

Report Date: **11-12-2019**

Client **Quantum Geotechnic Ltd**
Ty Berwig
Bynea
Llanelli.
Carmarthenshire.
SA14 9ST

Contract Title: **A40 RCE**
For the attention of: **Hugh Woodroffe**

Date Received: **15-11-2019**
Date Completed: **11-12-2019**

Test Description	Qty
Moisture Content BS 1377:1990 - Part 2 : 3.2 - * UKAS	74
4 Point Liquid & Plastic Limit BS 1377:1990 - Part 2 : 4.3 & 5.3 - * UKAS	74
PSD Wet Sieve method BS 1377:1990 - Part 2 : 9.2 - * UKAS	34
PSD: Sedimentation by pipette carried out separately BS 1377:1990 - Part 2 : 9.4 - * UKAS	34
Organic Matter Content-dichromate method BS 1377:1990 - Part 3 : 3 - @ Non Accredited Test	12
Loss on Ignition BS 1377:1990 - Part 3 : 4 - @ Non Accredited Test	13

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
 # - denotes test carried out by approved contractor
@ - denotes non accredited tests

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved Signatories:
Emma Sharp (Office Manager) - Paul Evans (Quality/Technical Manager) - Richard John (Advanced Testing Manager)
Sean Penn (Administrative/Accounts Assistant) - Shaun Jones (Laboratory manager) - Wayne Honey (Administrative/Quality Assistant)

GEO Site & Testing Services Ltd
Unit 3-4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

Laboratory Report

2788

GEO Site & Testing Services Ltd

Contract Number: 46614

Test Description	Qty
BRE Suite B Greenfield Site (pyrite present) includes pH, water & acid soluble sulphate and total sulphur BRE - BR279 - @ Non Accredited Test	12
Dry Den/MC (2.5kg Rammer Method 1 Litre Mould) BS 1377:1990 - Part 4 : 3.3 - * UKAS	5
Dry Den/MC (2.5kg Rammer Method CBR Mould) BS 1377:1990 - Part 4 : 3.4 - * UKAS	4
MCV/Moisture Content Relation BS 1377:1990 - Part 4 : 5.5 - * UKAS	5
One-dimensional Consolidation 75mm or 50mm diameter specimens (5 days) BS 1377:1990 - Part 5 : 3 - * UKAS	7
As 5.01, 5.03 & 5.04 each extra additional day BS 1377:1990 - Part 5 : 3	8
Quick Undrained Triaxial Compression Test - Multi-stage Loading of a single specimen (100mm diameter) BS 1377:1990 - Part 7 : 9 - * UKAS	4
Disposal of samples for job	1

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
 # - denotes test carried out by approved contractor
@ - denotes non accredited tests

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved Signatories:
Emma Sharp (Office Manager) - Paul Evans (Quality/Technical Manager) - Richard John (Advanced Testing Manager)
Sean Penn (Administrative/Accounts Assistant) - Shaun Jones (Laboratory manager) - Wayne Honey (Administrative/Quality Assistant)

GEO Site & Testing Services Ltd
Unit 3-4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-TP05	3		0.50	-	0.60	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP05	5		1.00	-	1.10	Brown silty clayey fine to coarse GRAVEL with shale.
RCE-TP05	6		2.00	-	2.50	Brown silty clayey fine to coarse GRAVEL with shale.
RCE-TP19	4		0.60	-	0.70	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP19	5		1.00	-	1.50	Brown silty clayey fine to coarse GRAVEL.
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		

Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	**46614**	
Project Location	**A40 RCE**	
Date Tested	**26/11/2019**	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-TP05	3		0.50	-	0.60	31	64	34	30	70	MH High Plasticity
RCE-TP05	5		1.00	-	1.10	13		NP		25	
RCE-TP05	6		2.00	-	2.50	9.3		NP		10	
RCE-TP19	4		0.60	-	0.70	18	36	16	20	80	CI Intermediate Plasticity
RCE-TP19	5		1.00	-	1.50	9.0		NP		20	
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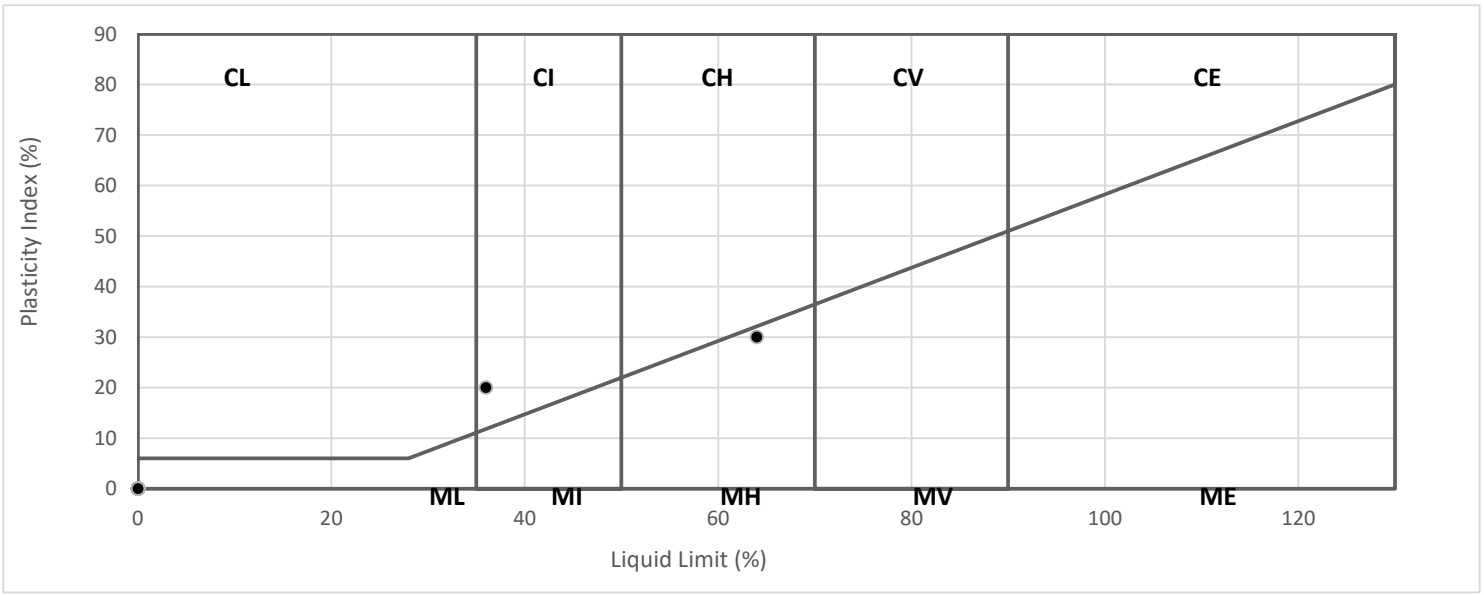
Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-BH01	2	B	0.40	-	1.00	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH02	2	B	0.50	-	0.80	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH02	5	B	1.20	-	2.00	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH05	4	UT	1.20	-	1.65	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH05	8	UT	2.00	-	2.45	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH05	12	UT	3.00	-	3.45	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH05	16	UT	4.00	-	4.20	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH05	19	UT	5.00	-	5.45	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH07	8	UT	2.20	-	2.45	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH07	12	UT	3.00	-	3.45	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH07	17	B	4.00	-	4.50	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH07	21	B	6.50	-	7.00	Brown fine to medium sandy gravelly silty CLAY.
RCE-BH07	23	B	8.00	-	8.50	Brown clayey SILTSTONE containing shale.
RCE-BH08	4	UT	1.20	-	1.65	Greyish brown fine to medium sandy gravelly silty CLAY.
RCE-BH08	7	UT	2.20	-	2.65	Greyish brown fine to medium sandy gravelly silty CLAY.
RCE-BH08	11	UT	3.20	-	3.65	Greyish brown fine to medium sandy gravelly silty CLAY.
RCE-BH09	5	B	1.60	-	2.00	Brown clayey SILTSTONE containing shale.
RCE-BH15	2	B	0.50	-	1.00	Brown fine to medium sandy gravelly silty CLAY.
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Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Project Location	A40 RCE	
Date Tested	26/11/2019	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-BH01	2	B	0.40	-	1.00	27	50	15	35	85	CI/H Inter/High Plasticity
RCE-BH02	2	B	0.50	-	0.80	10	41	19	22	50	CI Intermediate Plasticity
RCE-BH02	5	B	1.20	-	2.00	17	33	18	15	70	CL Low Plasticity
RCE-BH05	4	UT	1.20	-	1.65	13	28	12	16	80	CL Low Plasticity
RCE-BH05	8	UT	2.00	-	2.45	18	35	15	20	85	CL/I Low/Inter. Plasticity
RCE-BH05	12	UT	3.00	-	3.45	11	34	15	19	78	CL Low Plasticity
RCE-BH05	16	UT	4.00	-	4.20						
RCE-BH05	19	UT	5.00	-	5.45	13	34	15	19	80	CL Low Plasticity
RCE-BH07	8	UT	2.20	-	2.45	16	37	18	19	73	CI Intermediate Plasticity
RCE-BH07	12	UT	3.00	-	3.45	13	29	13	16	90	CL Low Plasticity
RCE-BH07	17	B	4.00	-	4.50	19	35	17	18	85	CL/I Low/Inter. Plasticity
RCE-BH07	21	B	6.50	-	7.00	20	35	23	12	70	CL/I Low/Inter. Plasticity
RCE-BH07	23	B	8.00	-	8.50	14	31	14	17	85	CL Low Plasticity
RCE-BH08	4	UT	1.20	-	1.65	14	26	11	15	90	CL Low Plasticity
RCE-BH08	7	UT	2.20	-	2.65	14	49	18	31	72	CI Intermediate Plasticity
RCE-BH08	11	UT	3.20	-	3.65	12	28	12	16	90	CL Low Plasticity
RCE-BH09	5	B	1.60	-	2.00	7.7		NP		20	
RCE-BH15	2	B	0.50	-	1.00	12	25	11	14	75	CL Low Plasticity
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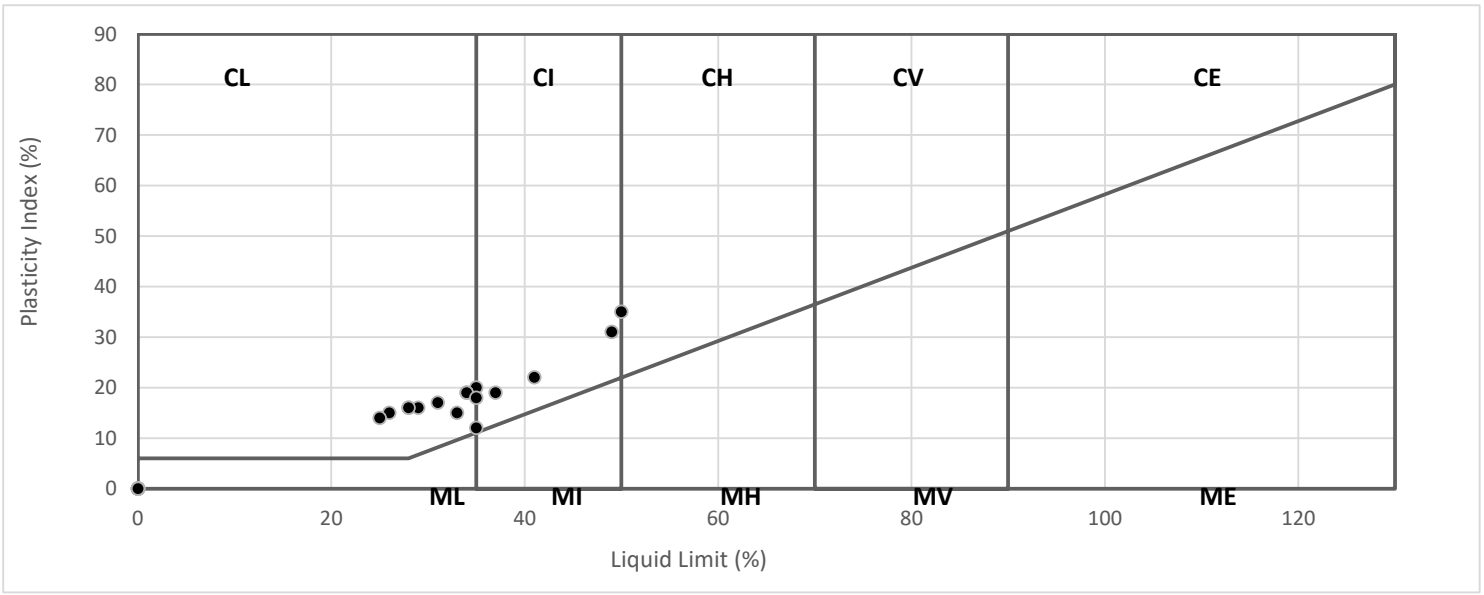
Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-BH04	2	B	0.50	-	1.00	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH04	5	B	1.20	-	1.50	Brown silty clayey fine to medium sandy GRAVEL.
RCE-BH06	2	B	0.50	-		Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	4	UT	1.20	-		Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	8	UT	2.00	-	3.45	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	11	B	2.50	-	3.00	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	12	UT	3.00	-	3.45	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	16	UT	4.00	-	4.45	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	20	UT	5.00	-	5.45	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH06	23	B	6.30	-	6.50	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH12	5	B	1.20	-	1.50	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH12	8	B	2.00	-	2.50	Brown fine to medium gravelly sandy silty CLAY.
RCE-BH13	3	B	1.00	-		Brown fine to medium gravelly sandy silty CLAY.
RCE-BH14	5	B	1.20	-	1.70	Brown fine to medium gravelly sandy silty CLAY.
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Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Project Location	A40 RCE	
Date Tested	26/11/2019	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-BH04	2	B	0.50	-	1.00	13	33	17	16	50	CL Low Plasticity
RCE-BH04	5	B	1.20	-	1.50	15		NP		15	
RCE-BH06	2	B	0.50	-		24	39	20	19	83	CI Intermediate Plasticity
RCE-BH06	4	UT	1.20	-		11	33	14	19	83	CL Low Plasticity
RCE-BH06	8	UT	2.00	-	3.45	13	43	16	27	91	CI Intermediate Plasticity
RCE-BH06	11	B	2.50	-	3.00	15	28	12	16	90	CL Low Plasticity
RCE-BH06	12	UT	3.00	-	3.45	14	31	12	19	87	CL Low Plasticity
RCE-BH06	16	UT	4.00	-	4.45	13	29	11	18	90	CL Low Plasticity
RCE-BH06	20	UT	5.00	-	5.45						
RCE-BH06	23	B	6.30	-	6.50	19	34	17	17	80	CL Low Plasticity
RCE-BH12	5	B	1.20	-	1.50	15	34	11	23	90	CL Low Plasticity
RCE-BH12	8	B	2.00	-	2.50	15	36	20	16	45	CI Intermediate Plasticity
RCE-BH13	3	B	1.00	-		17	38	15	23	83	CI Intermediate Plasticity
RCE-BH14	5	B	1.20	-	1.70	19	44	16	28	73	CI Intermediate Plasticity
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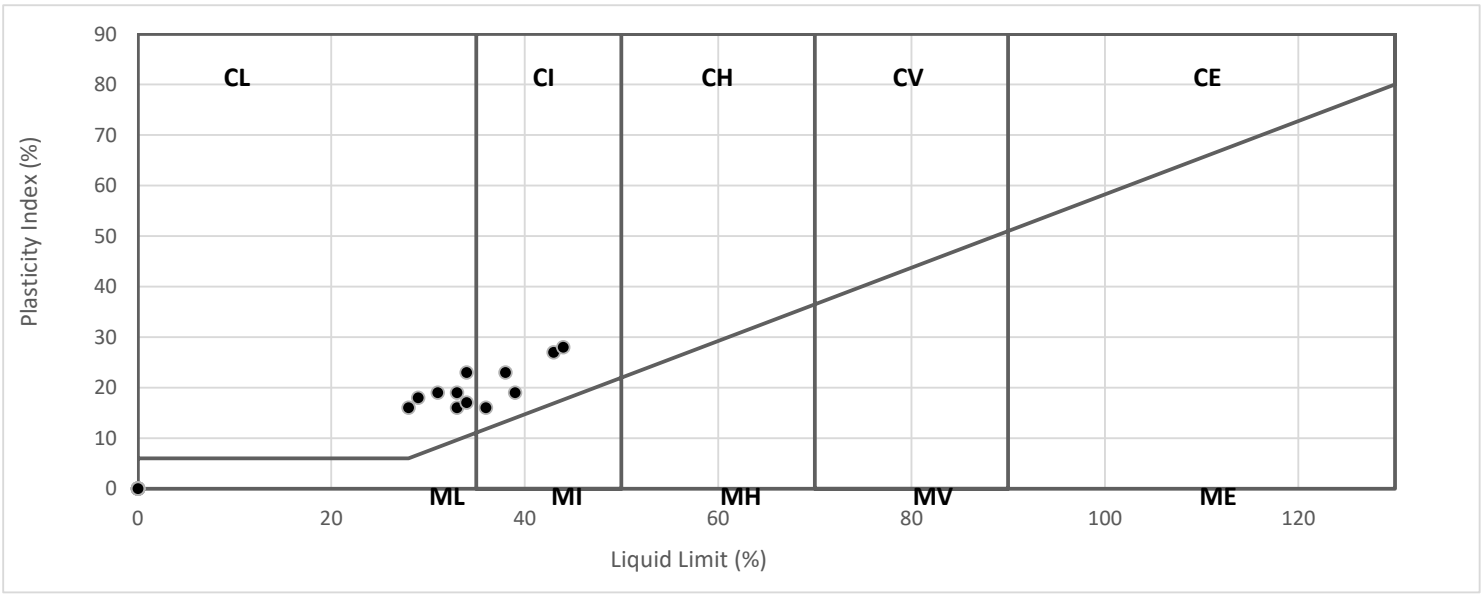
Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-TP01	3	B	0.50	-	1.00	Brown fine to medium gravelly silty CLAY.
RCE-TP01	5	B	1.50	-	2.00	Brown fine to medium gravelly silty CLAY.
RCE-TP02	3	B	0.50	-	1.00	Brown fine to medium gravelly silty CLAY.
RCE-TP02	5	B	1.50	-	2.00	Brown fine to medium gravelly silty CLAY.
RCE-TP03	3	B	0.50	-	1.00	Brown fine to medium gravelly silty CLAY.
RCE-TP03	6	B	2.50	-	3.00	Brown fine to medium gravelly silty CLAY.
RCE-TP04	3	B	0.30	-	0.70	Brown fine to medium gravelly silty CLAY.
RCE-TP04	4	B	1.00	-	1.50	Brown silty clayey fine to coarse sandy GRAVEL.
RCE-TP11	3	B	0.50	-	1.00	Brown fine to medium gravelly silty CLAY.
RCE-TP11	5	B	1.50	-	2.00	Brown fine to medium gravelly silty CLAY.
RCE-TP11	6	B	2.50	-	3.00	Brown silty clayey fine to coarse sandy GRAVEL.
RCE-TP12	3	B	0.50	-	1.00	Brown fine to coarse gravelly silty CLAY.
RCE-TP12	4	B	1.10	-	1.20	Brown fine to medium gravelly silty CLAY.
RCE-TP12	6	B	1.50	-	2.00	Brown fine to coarse gravelly silty CLAY.
RCE-TP12	8	B	3.00	-	3.50	Brown fine to medium gravelly silty CLAY.
RCE-SA12	2	B	0.50	-	1.00	Brown fine to medium gravelly silty CLAY.
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Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Project Location	A40 RCE	
Date Tested	26/11/2019	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-TP01	3	B	0.50	-	1.00	16	34	15	19	80	CL Low Plasticity
RCE-TP01	5	B	1.50	-	2.00	14	27	13	14	75	CL Low Plasticity
RCE-TP02	3	B	0.50	-	1.00	14	31	16	15	45	CL Low Plasticity
RCE-TP02	5	B	1.50	-	2.00	16	27	14	13	35	CL Low Plasticity
RCE-TP03	3	B	0.50	-	1.00	19	27	13	14	64	CL Low Plasticity
RCE-TP03	6	B	2.50	-	3.00	12	22	10	12	60	CL Low Plasticity
RCE-TP04	3	B	0.30	-	0.70	24	42	19	23	90	CI Intermediate Plasticity
RCE-TP04	4	B	1.00	-	1.50	13		NP		25	
RCE-TP11	3	B	0.50	-	1.00	27	45	19	26	98	CI Intermediate Plasticity
RCE-TP11	5	B	1.50	-	2.00	12	29	14	15	80	CL Low Plasticity
RCE-TP11	6	B	2.50	-	3.00	13		NP		15	
RCE-TP12	3	B	0.50	-	1.00	27	44	19	25	85	CI Intermediate Plasticity
RCE-TP12	4	B	1.10	-	1.20	19	36	17	19	90	CI Intermediate Plasticity
RCE-TP12	6	B	1.50	-	2.00	15	37	18	19	60	CI Intermediate Plasticity
RCE-TP12	8	B	3.00	-	3.50	18	28	16	12	85	CL Low Plasticity
RCE-SA12	2	B	0.50	-	1.00	14	29	16	13	80	CL Low Plasticity
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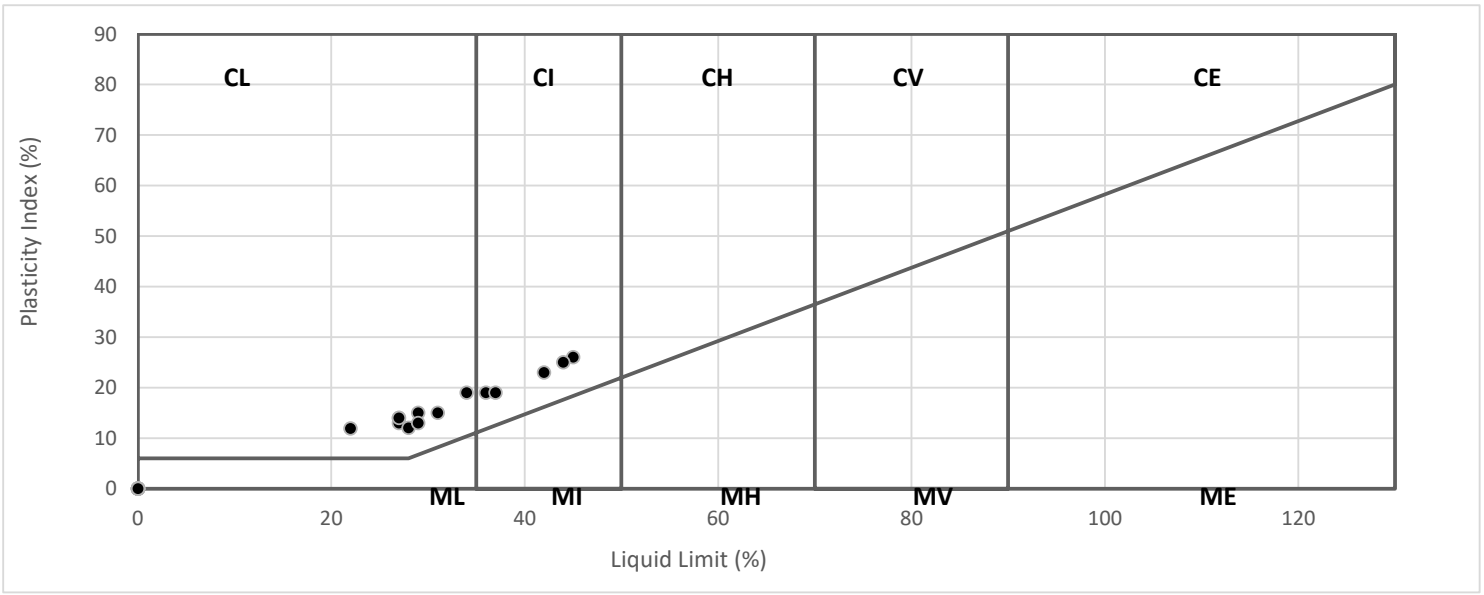
Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-TP06	4	B	0.50	-	1.00	Brown silty clayey fine to coarse GRAVEL containing shale.
RCE-TP06	5	B	1.50	-	2.00	Brown silty clayey fine to coarse GRAVEL.
RCE-TP06	6	B	2.50	-	2.70	Brown fine to coarse sandy gravelly silty CLAY.
RCE-TP07	5	B	1.00	-	1.50	Brown fine to coarse sandy gravelly silty CLAY.
RCE-TP07	6	B	2.00	-	2.50	Brown fine to coarse sandy gravelly silty CLAY.
RCE-TP13	4	B	0.50	-	1.00	Brown fine to coarse sandy gravelly silty CLAY.
RCE-TP13	5	B	1.50	-	2.00	Brown silty clayey fine to coarse GRAVEL containing shale.
RCE-TP14	3	B	0.50	-	0.70	Brown fine to coarse sandy gravelly silty CLAY.
RCE-TP14	4	B	1.00	-	1.50	Brown silty clayey fine to coarse GRAVEL
RCE-TP14	6	B	2.20	-	2.50	Brown silty clayey fine to coarse GRAVEL
RCE-TP15	4	B	0.50	-	1.00	Brown silty clayey fine to coarse GRAVEL
RCE-TP15	5	B	1.50	-	1.70	Brown silty clayey fine to coarse GRAVEL
RCE-TP18	3	B	0.50	-	0.90	Brown silty clayey fine to coarse GRAVEL
RCE-TP18	5	B	1.50	-	2.00	Brown silty clayey fine to coarse GRAVEL containing shale.
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Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	**46614**	
Project Location	**A40 RCE**	
Date Tested	**26/11/2019**	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-TP06	4	B	0.50	-	1.00	12		NP		30	
RCE-TP06	5	B	1.50	-	2.00	8.7		NP		31	
RCE-TP06	6	B	2.50	-	2.70	8.0	39	16	23	60	CI Intermediate Plasticity
RCE-TP07	5	B	1.00	-	1.50	14	31	19	12	60	CL Low Plasticity
RCE-TP07	6	B	2.00	-	2.50	15	25	14	11	40	CL Low Plasticity
RCE-TP13	4	B	0.50	-	1.00	14	31	13	18	80	CL Low Plasticity
RCE-TP13	5	B	1.50	-	2.00	15		NP		20	
RCE-TP14	3	B	0.50	-	0.70	21	38	23	15	80	CI Intermediate Plasticity
RCE-TP14	4	B	1.00	-	1.50	8.6		NP		20	
RCE-TP14	6	B	2.20	-	2.50	6.7		NP		20	
RCE-TP15	4	B	0.50	-	1.00	10		NP		21	
RCE-TP15	5	B	1.50	-	1.70	8.1		NP		23	
RCE-TP18	3	B	0.50	-	0.90	18		NP		24	
RCE-TP18	5	B	1.50	-	2.00	9.4		NP		29	
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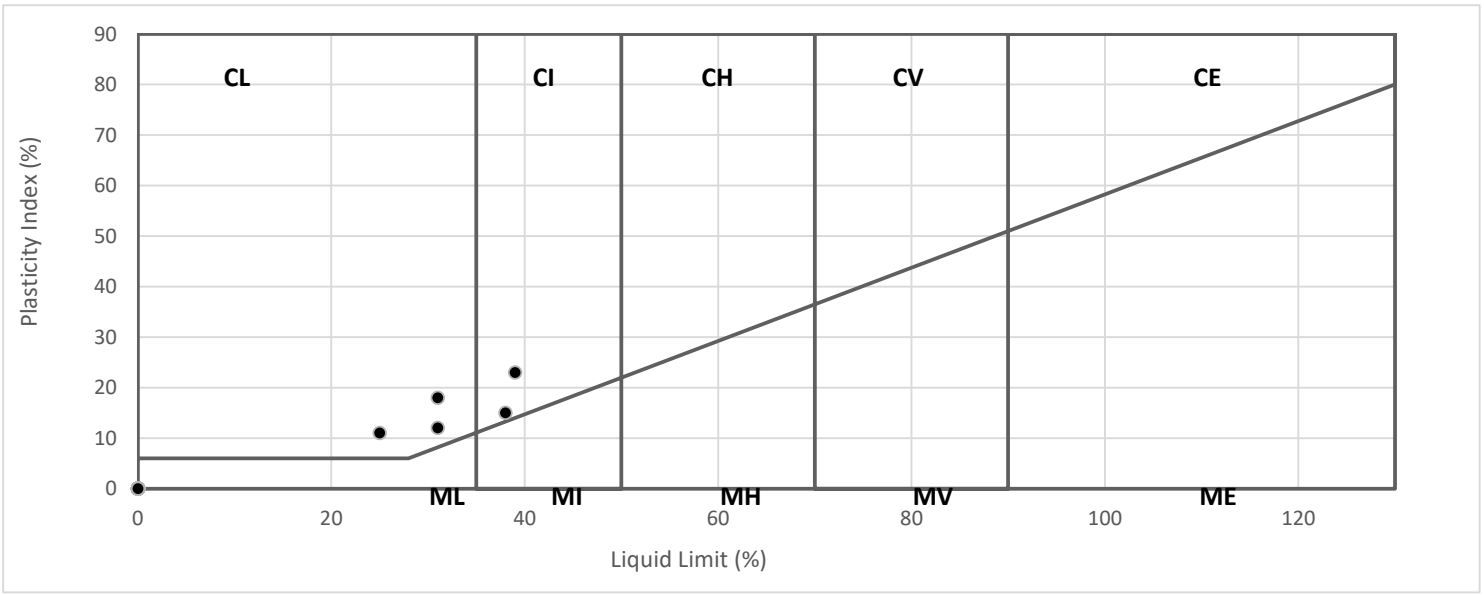
Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Site Name	A40 RCE	
Date Tested	26/11/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCE-TP08	3	B	0.50	-	1.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP08	6	B	2.50	-	2.90	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP08	7	B	3.50	-	4.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP09	3	B	0.50	-	1.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP09	5	B	1.50	-	2.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP09	6	B	2.50	-	3.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP10	3	B	0.50	-	1.00	Brown fine to coarse gravelly sandy silty CLAY.
RCE-TP10	6	B	1.50	-	2.00	Brown clayey silty fine to coarse gravelly SAND.
RCE-TP10	5	B	2.50	-	3.00	Brown fine to coarse gravelly sandy silty CLAY.
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Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
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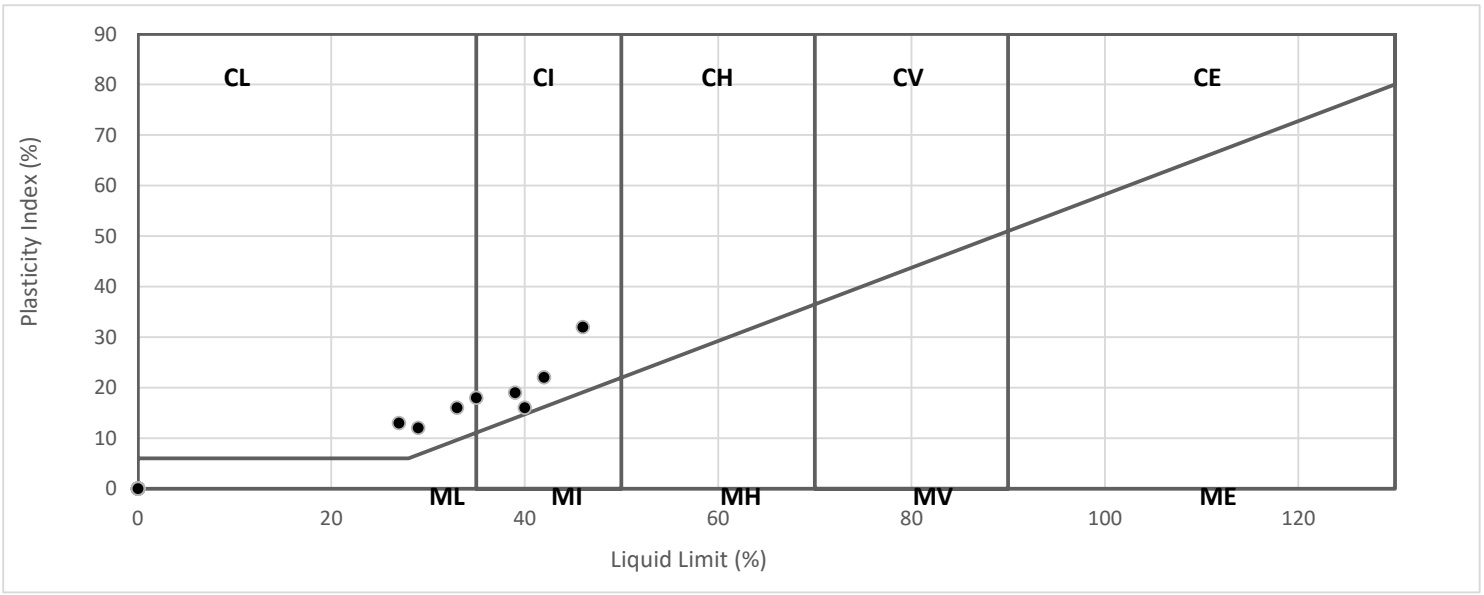
GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46614	
Project Location	A40 RCE	
Date Tested	26/11/2019	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCE-TP08	3	B	0.50	-	1.00	15	27	14	13	85	CL Low Plasticity
RCE-TP08	6	B	2.50	-	2.90	23	42	20	22	85	CI Intermediate Plasticity
RCE-TP08	7	B	3.50	-	4.00	14	33	17	16	85	CL Low Plasticity
RCE-TP09	3	B	0.50	-	1.00	20	35	17	18	90	CL/I Low/Inter. Plasticity
RCE-TP09	5	B	1.50	-	2.00	16	46	14	32	91	CI Intermediate Plasticity
RCE-TP09	6	B	2.50	-	3.00	18	29	17	12	85	CL Low Plasticity
RCE-TP10	3	B	0.50	-	1.00	23	39	20	19	90	CI Intermediate Plasticity
RCE-TP10	6	B	1.50	-	2.00	12		NP		25	
RCE-TP10	5	B	2.50	-	3.00	27	40	24	16	90	CI Intermediate Plasticity
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							

Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

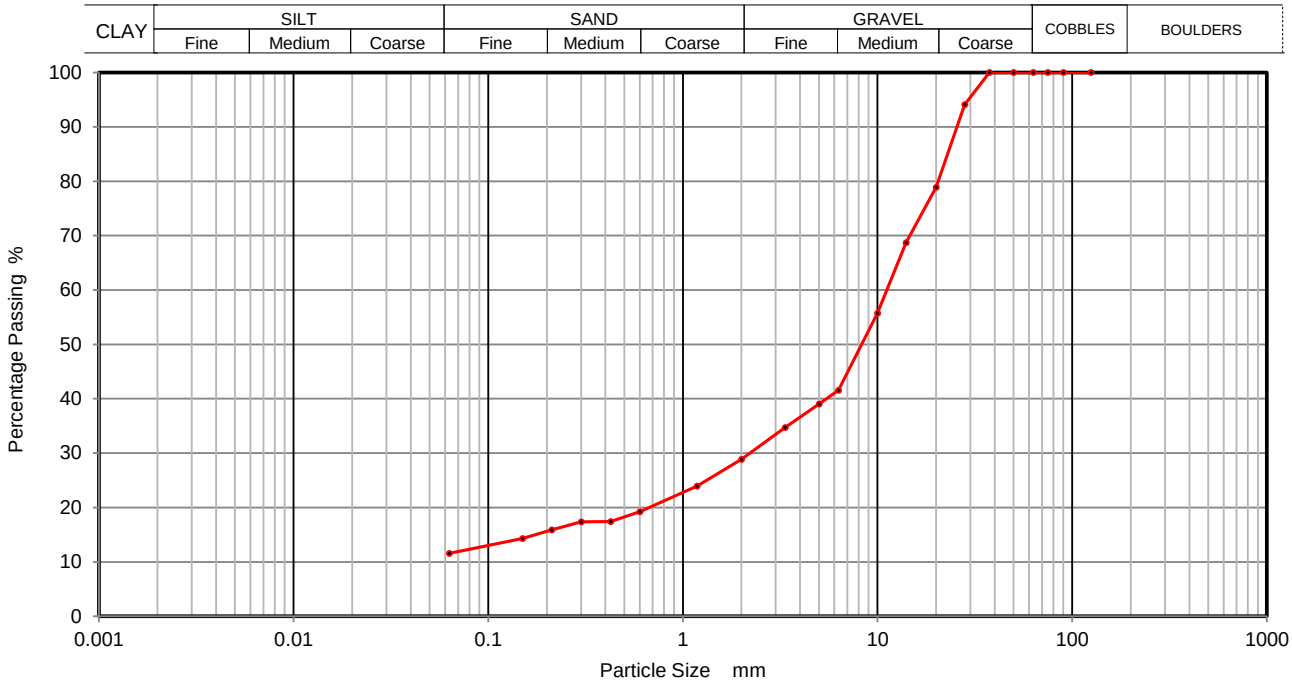
PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	11/12/2019	Wayne Honey (Administrative/Quality Assistant)
Dean Smith	Approved	11/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH02
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown silty clayey fine to coarse sandy fine to coarse GRAVEL.	Depth Top	0.50
		Depth Base	0.80
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	94		
20	79		
14	69		
10	56		
6.3	42		
5	39		
3.35	35		
2	29		
1.18	24		
0.6	19		
0.425	17		
0.3	17		
0.212	16		
0.15	14		
0.063	12		

Sample Proportions	% dry mass
Cobbles	0
Gravel	71
Sand	17
Silt and Clay	12

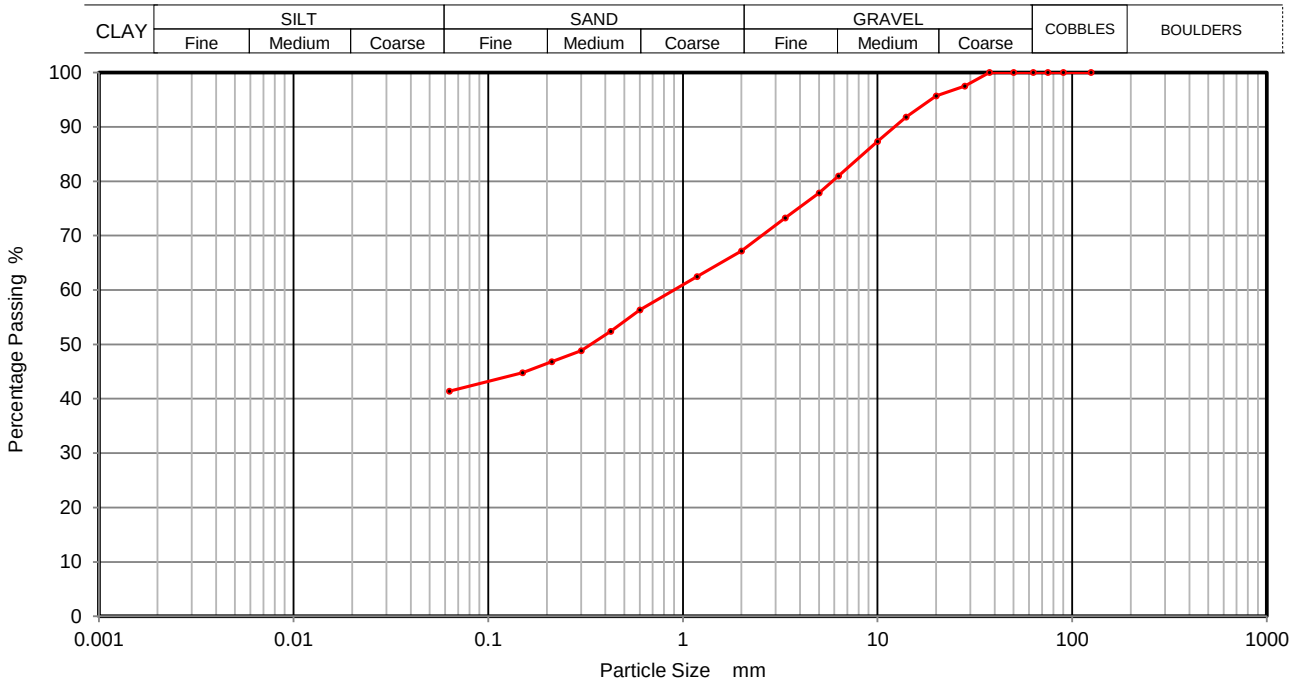
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH02
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to coarse sandy fine to coarse gravelly silty CLAY.	Depth Top	1.20
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	97		
20	96		
14	92		
10	87		
6.3	81		
5	78		
3.35	73		
2	67		
1.18	62		
0.6	56		
0.425	52		
0.3	49		
0.212	47		
0.15	45		
0.063	41		

Sample Proportions	% dry mass
Cobbles	0
Gravel	33
Sand	26
Silt and Clay	41

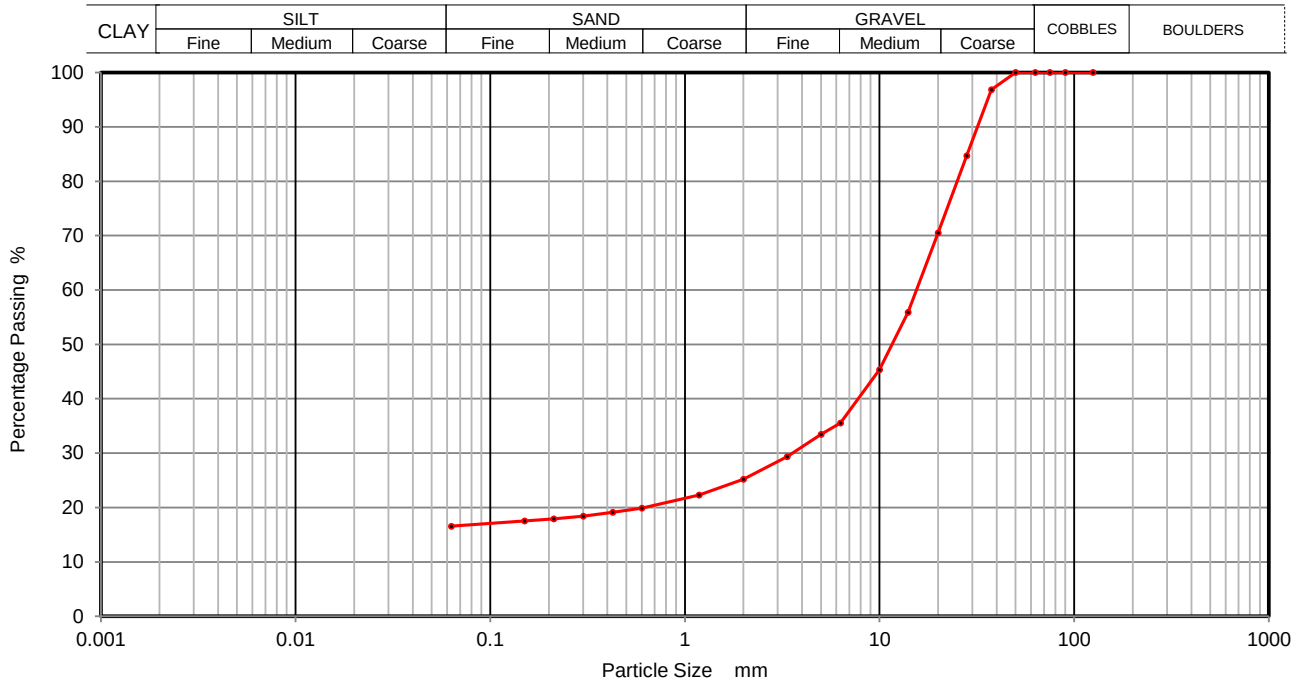
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH04
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown fine to medium slightly sandy silty clayey fine to coarse GRAVEL.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	97		
28	85		
20	71		
14	56		
10	45		
6.3	36		
5	33		
3.35	29		
2	25		
1.18	22		
0.6	20		
0.425	19		
0.3	18		
0.212	18		
0.15	18		
0.063	17		

Sample Proportions	% dry mass
Cobbles	0
Gravel	75
Sand	8
Silt and Clay	17

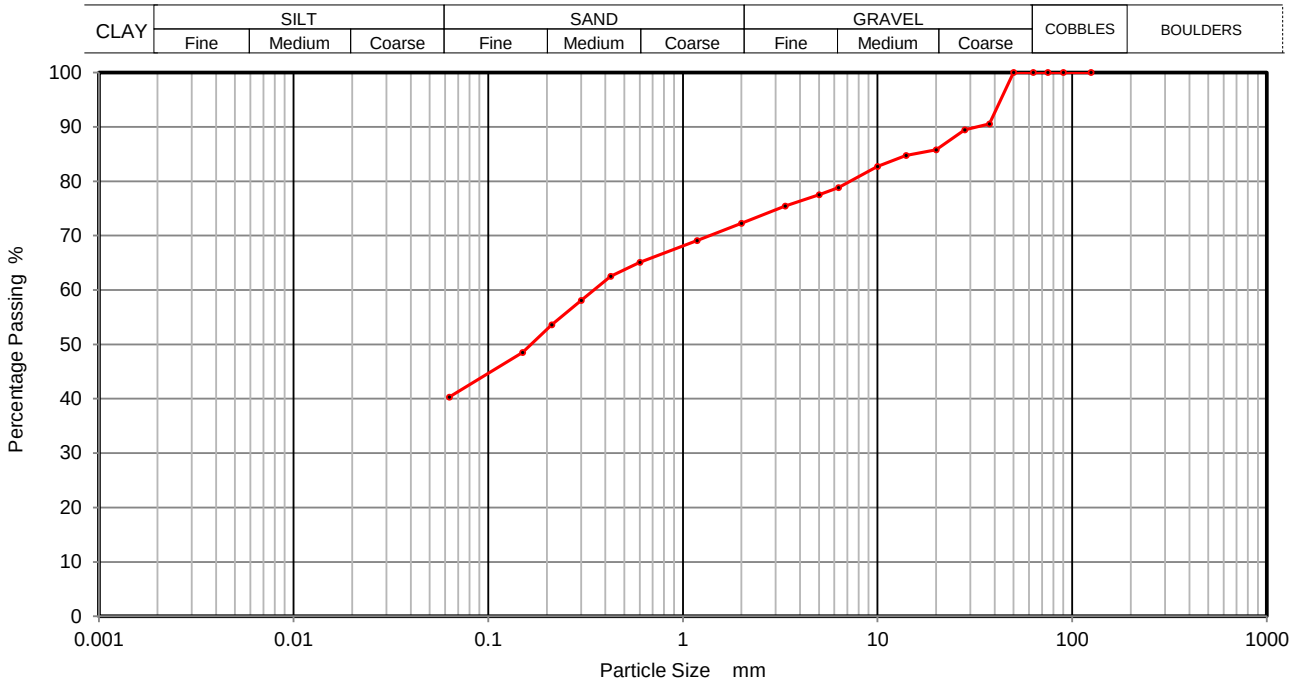
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	**PARTICLE SIZE DISTRIBUTION** **BS 1377 Part 2:1990** **Wet Sieve, Clause 9.2**	Contract Number	**46614**
		Borehole/Pit No.	**RCE-BH08**
Site Name	**A40 RCE**	Sample No.	**23**
Soil Description	Brown fine to coarse gravelly fine to coarse sandy silty CLAY.	Depth Top	**8.00**
		Depth Base	**8.50**
Date Tested	14/11/2019	Sample Type	**B**



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	91		
28	89		
20	86		
14	85		
10	83		
6.3	79		
5	78		
3.35	75		
2	72		
1.18	69		
0.6	65		
0.425	63		
0.3	58		
0.212	54		
0.15	49		
0.063	40		

Sample Proportions	% dry mass
Cobbles	0
Gravel	28
Sand	32
Silt and Clay	40

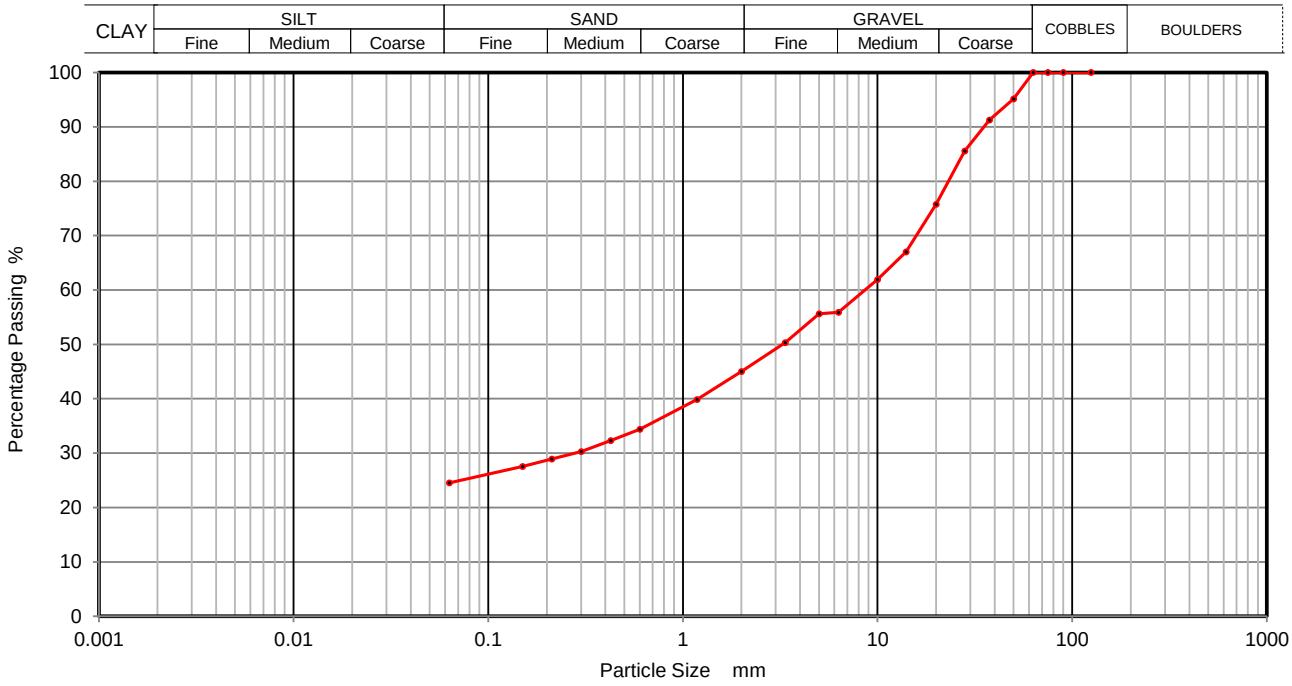
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH012
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine to coarse sandy silty clayey fine to coarse GRAVEL.	Depth Top	2.00
		Depth Base	2.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	91		
28	86		
20	76		
14	67		
10	62		
6.3	56		
5	56		
3.35	50		
2	45		
1.18	40		
0.6	34		
0.425	32		
0.3	30		
0.212	29		
0.15	28		
0.063	25		

Sample Proportions	% dry mass
Cobbles	0
Gravel	55
Sand	20
Silt and Clay	25

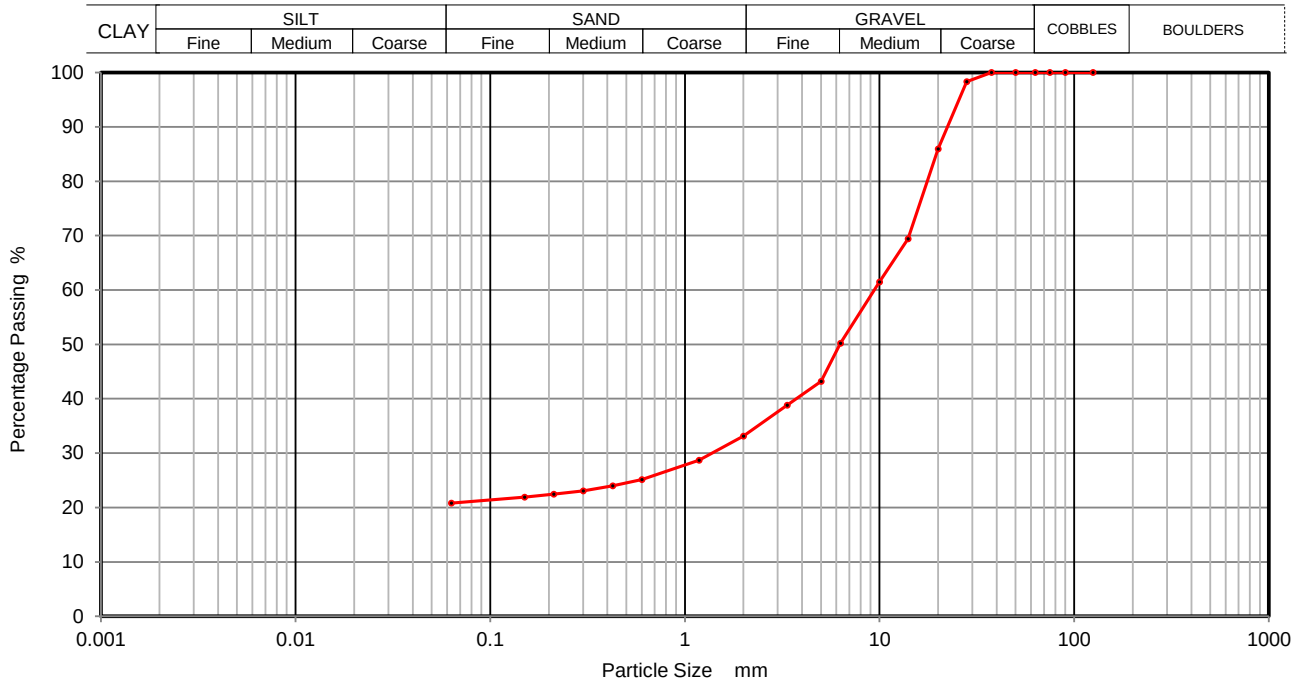
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH013
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine to coarse sandy silty clayey fine to coarse GRAVEL.	Depth Top	1.00
		Depth Base	
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	98		
20	86		
14	69		
10	61		
6.3	50		
5	43		
3.35	39		
2	33		
1.18	29		
0.6	25		
0.425	24		
0.3	23		
0.212	22		
0.15	22		
0.063	21		

Sample Proportions	% dry mass
Cobbles	0
Gravel	67
Sand	12
Silt and Clay	21

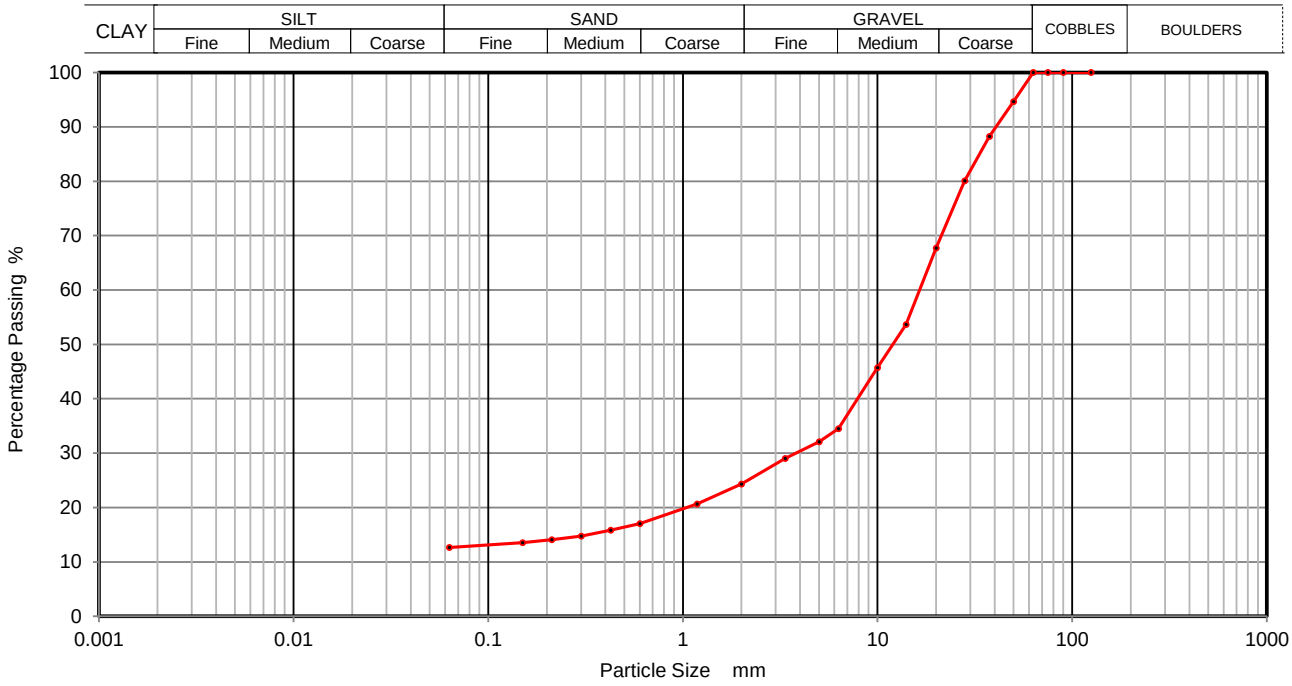
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-BH015
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown fine to medium slightly sandy silty clayey fine to coarse GRAVEL.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	88		
28	80		
20	68		
14	54		
10	46		
6.3	34		
5	32		
3.35	29		
2	24		
1.18	21		
0.6	17		
0.425	16		
0.3	15		
0.212	14		
0.15	14		
0.063	13		

Sample Proportions	% dry mass
Cobbles	0
Gravel	76
Sand	11
Silt and Clay	13

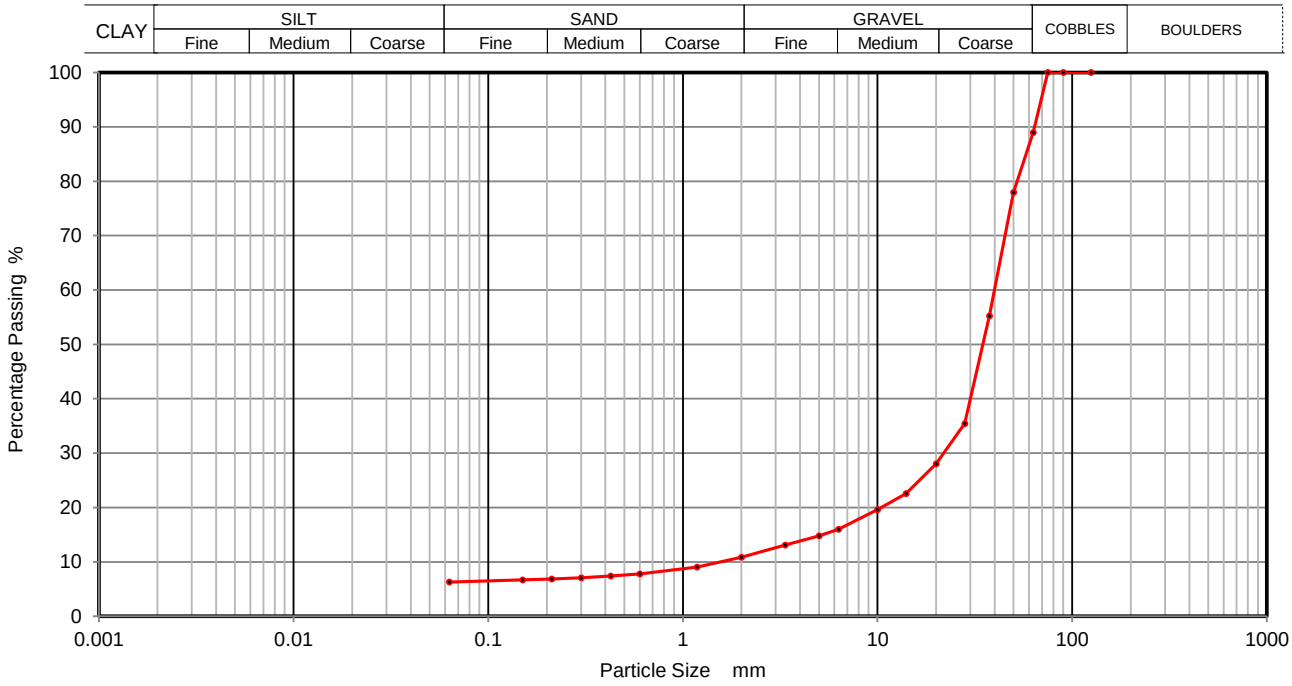
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP01
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL with few cobbles.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	89		
50	78		
37.5	55		
28	35		
20	28		
14	23		
10	20		
6.3	16		
5	15		
3.35	13		
2	11		
1.18	9		
0.6	8		
0.425	7		
0.3	7		
0.212	7		
0.15	7		
0.063	6		

Sample Proportions	% dry mass
Cobbles	11
Gravel	78
Sand	5
Silt and Clay	6

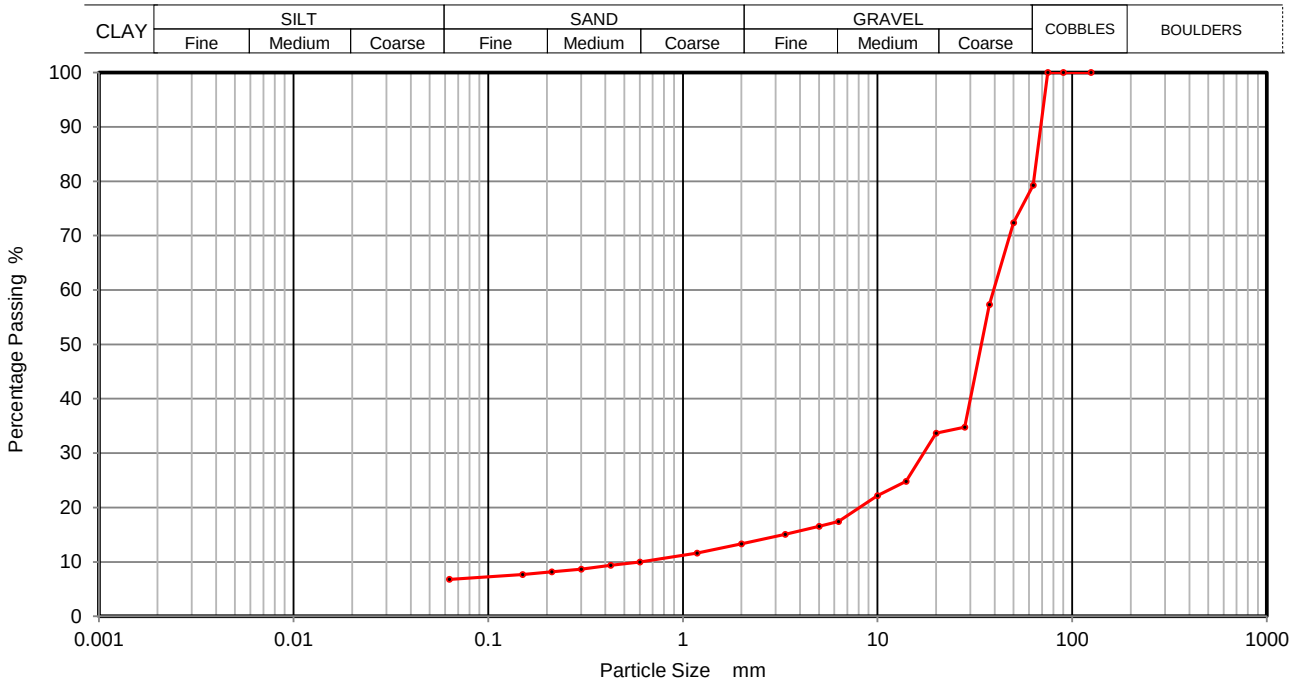
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP01
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL with many cobbles.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	79		
50	72		
37.5	57		
28	35		
20	34		
14	25		
10	22		
6.3	17		
5	17		
3.35	15		
2	13		
1.18	12		
0.6	10		
0.425	9		
0.3	9		
0.212	8		
0.15	8		
0.063	7		

Sample Proportions	% dry mass
Cobbles	21
Gravel	66
Sand	6
Silt and Clay	7

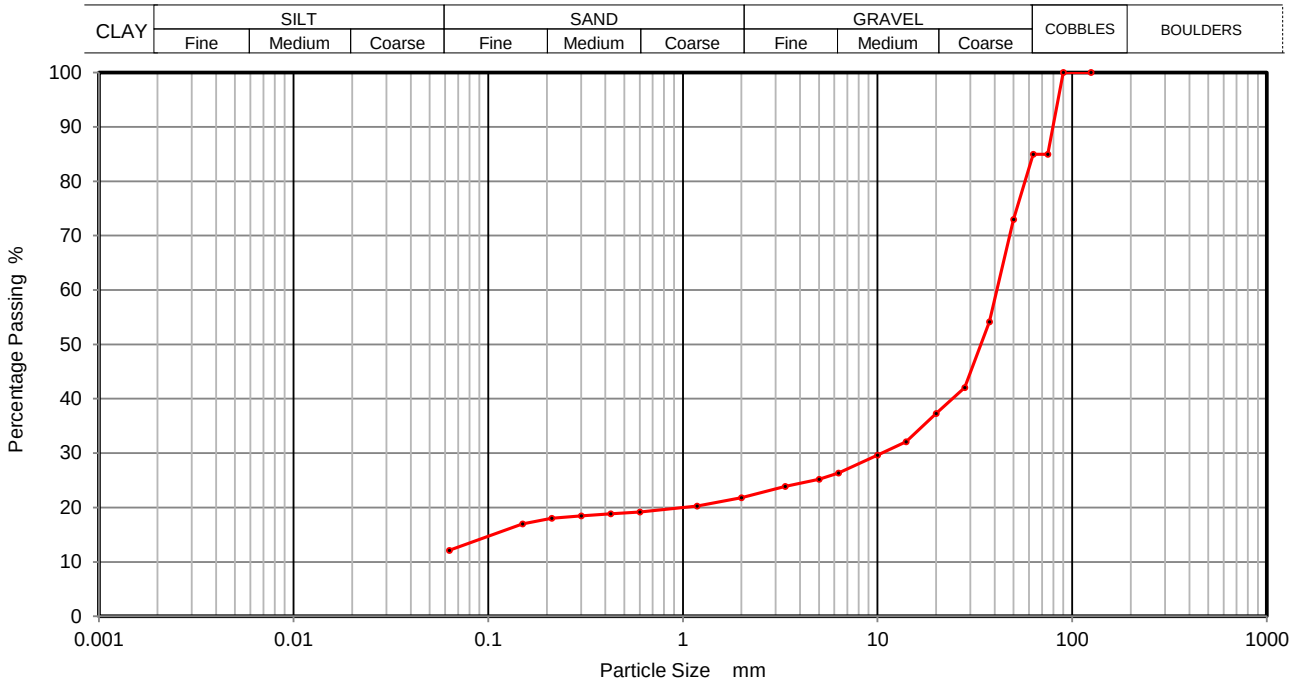
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP02
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL with many cobbles.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	85		
63	85		
50	73		
37.5	54		
28	42		
20	37		
14	32		
10	30		
6.3	26		
5	25		
3.35	24		
2	22		
1.18	20		
0.6	19		
0.425	19		
0.3	18		
0.212	18		
0.15	17		
0.063	12		

Sample Proportions	% dry mass
Cobbles	15
Gravel	63
Sand	10
Silt and Clay	12

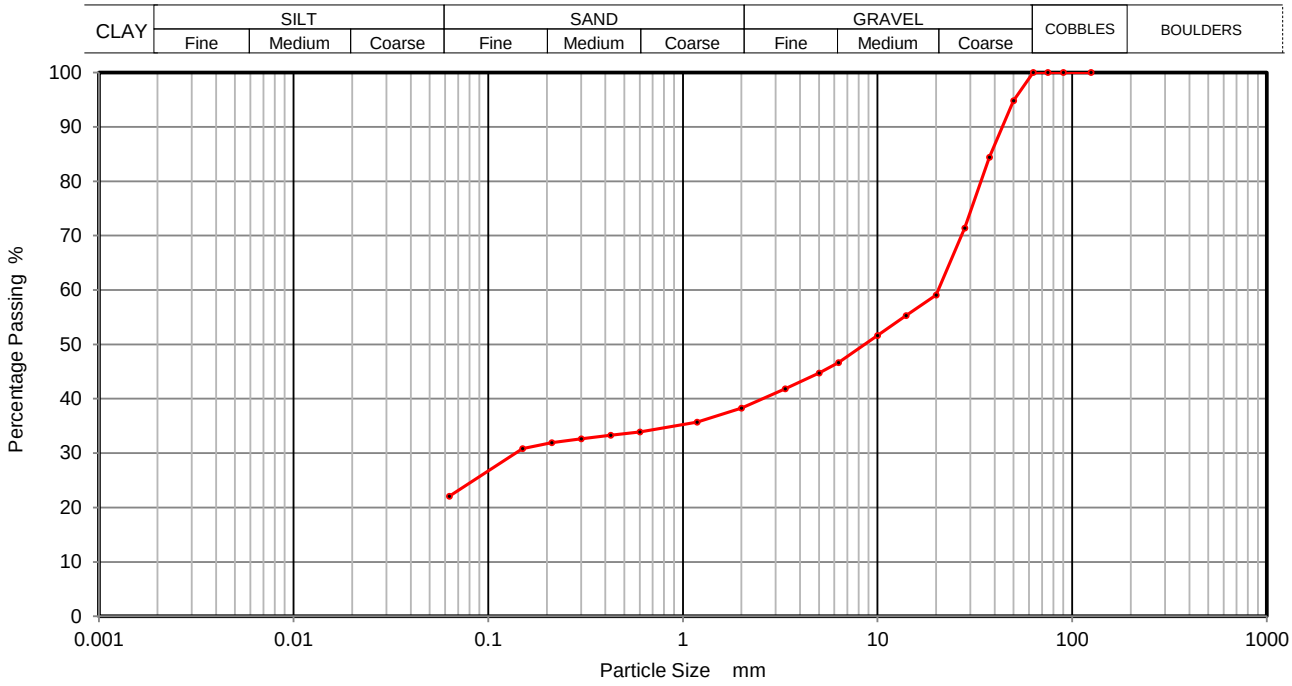
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP02
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to medium sandy silty clayey fine to coarse GRAVEL.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	84		
28	71		
20	59		
14	55		
10	52		
6.3	47		
5	45		
3.35	42		
2	38		
1.18	36		
0.6	34		
0.425	33		
0.3	33		
0.212	32		
0.15	31		
0.063	22		

Sample Proportions	% dry mass
Cobbles	0
Gravel	62
Sand	16
Silt and Clay	22

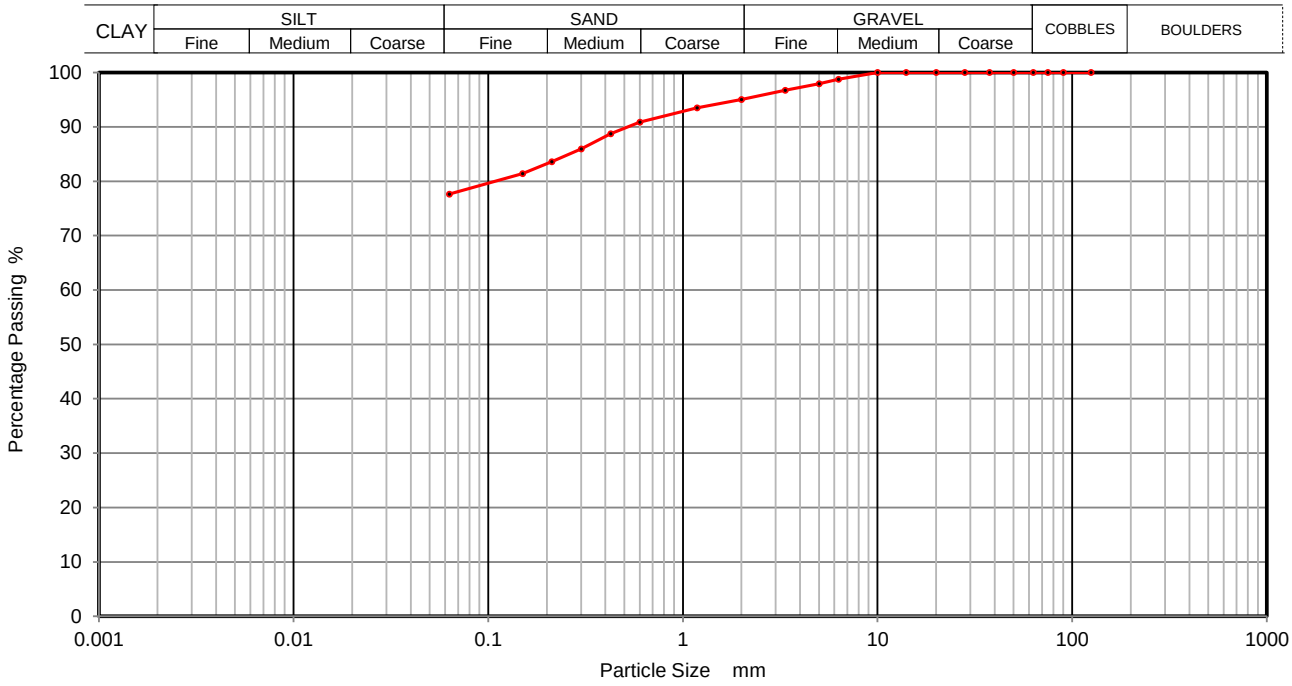
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP04
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine to medium slightly gravelly fine to coarse sandy silty CLAY.	Depth Top	0.30
		Depth Base	0.70
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	100		
10	100		
6.3	99		
5	98		
3.35	97		
2	95		
1.18	93		
0.6	91		
0.425	89		
0.3	86		
0.212	84		
0.15	81		
0.063	78		

Sample Proportions	% dry mass
Cobbles	0
Gravel	5
Sand	17
Silt and Clay	78

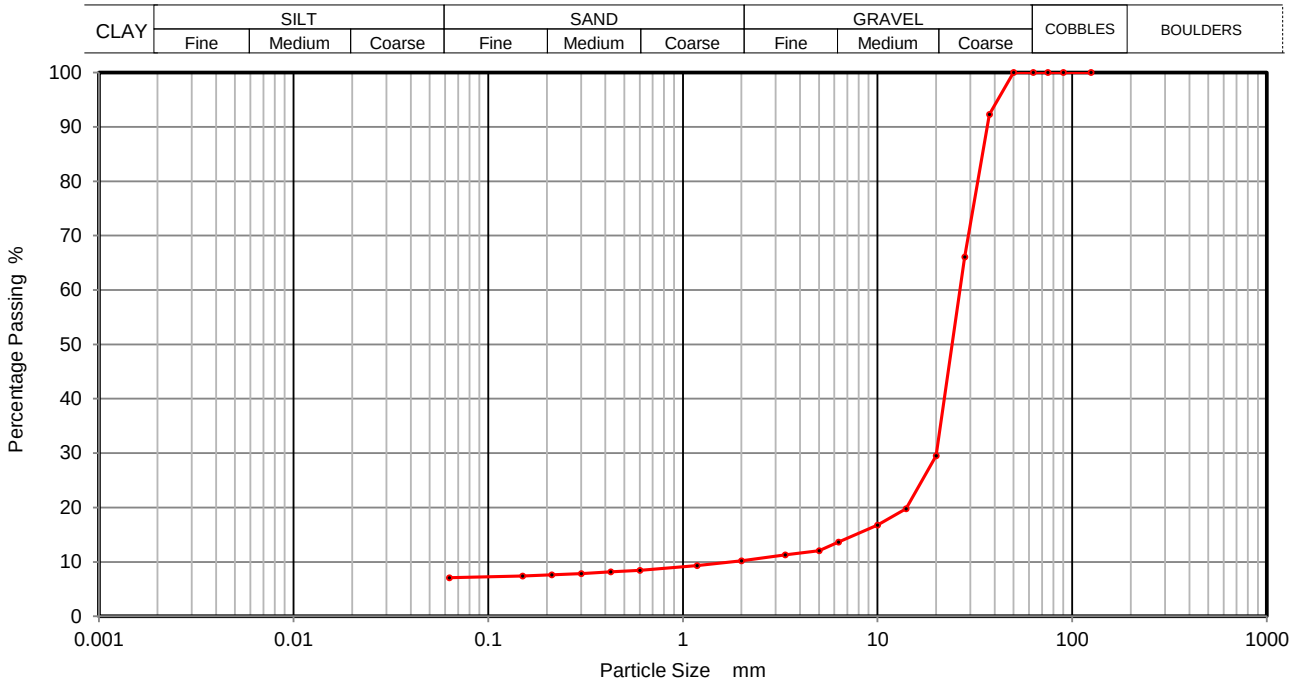
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP05
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL containing shale.	Depth Top	1.00
		Depth Base	1.10
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	92		
28	66		
20	30		
14	20		
10	17		
6.3	14		
5	12		
3.35	11		
2	10		
1.18	9		
0.6	8		
0.425	8		
0.3	8		
0.212	8		
0.15	7		
0.063	7		

Sample Proportions	% dry mass
Cobbles	0
Gravel	90
Sand	3
Silt and Clay	7

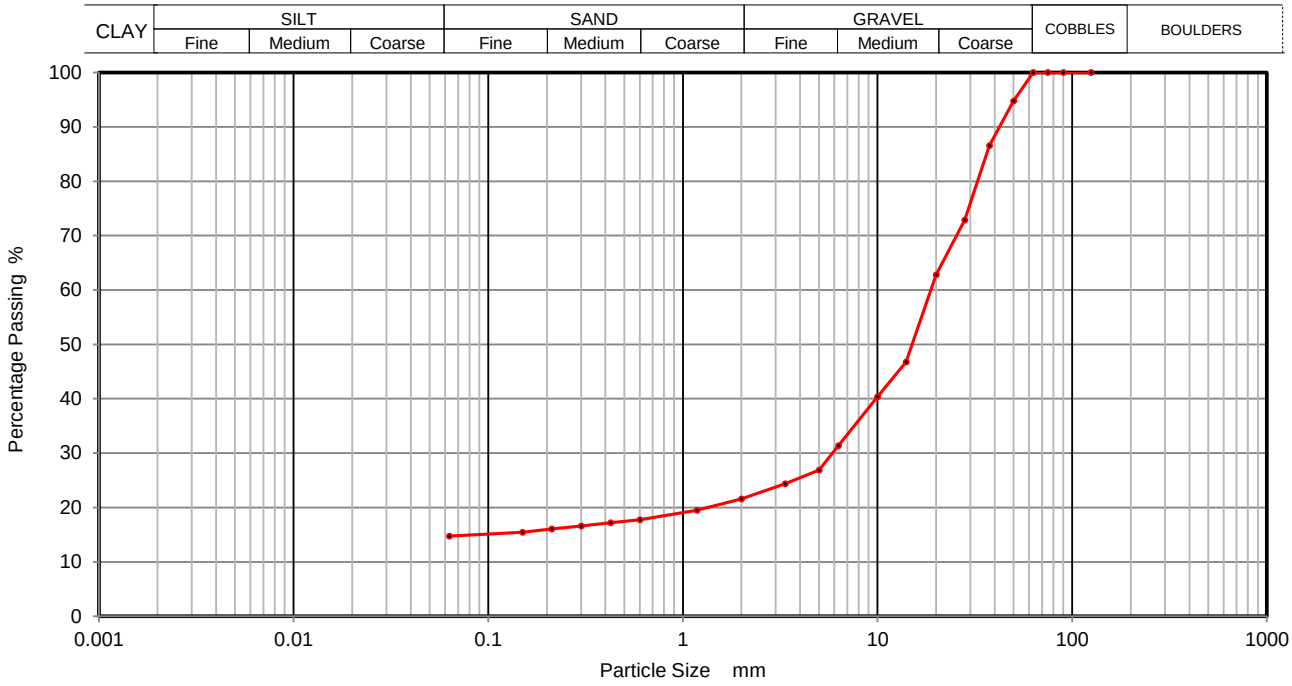
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP05
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL containing shale.	Depth Top	2.00
		Depth Base	2.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	87		
28	73		
20	63		
14	47		
10	40		
6.3	31		
5	27		
3.35	24		
2	22		
1.18	19		
0.6	18		
0.425	17		
0.3	17		
0.212	16		
0.15	15		
0.063	15		

Sample Proportions	% dry mass
Cobbles	0
Gravel	78
Sand	7
Silt and Clay	15

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
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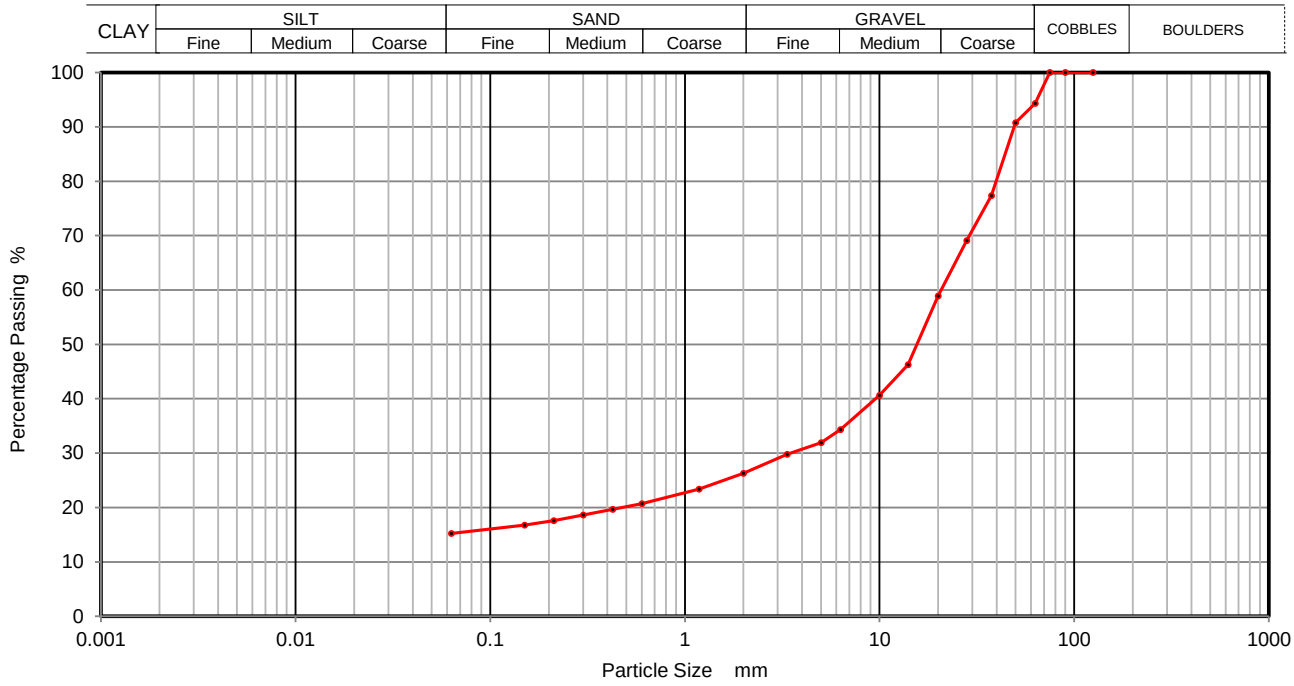
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP06
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL with few cobbles.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	94		
50	91		
37.5	77		
28	69		
20	59		
14	46		
10	41		
6.3	34		
5	32		
3.35	30		
2	26		
1.18	23		
0.6	21		
0.425	20		
0.3	19		
0.212	18		
0.15	17		
0.063	15		

Sample Proportions	% dry mass
Cobbles	6
Gravel	68
Sand	11
Silt and Clay	15

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
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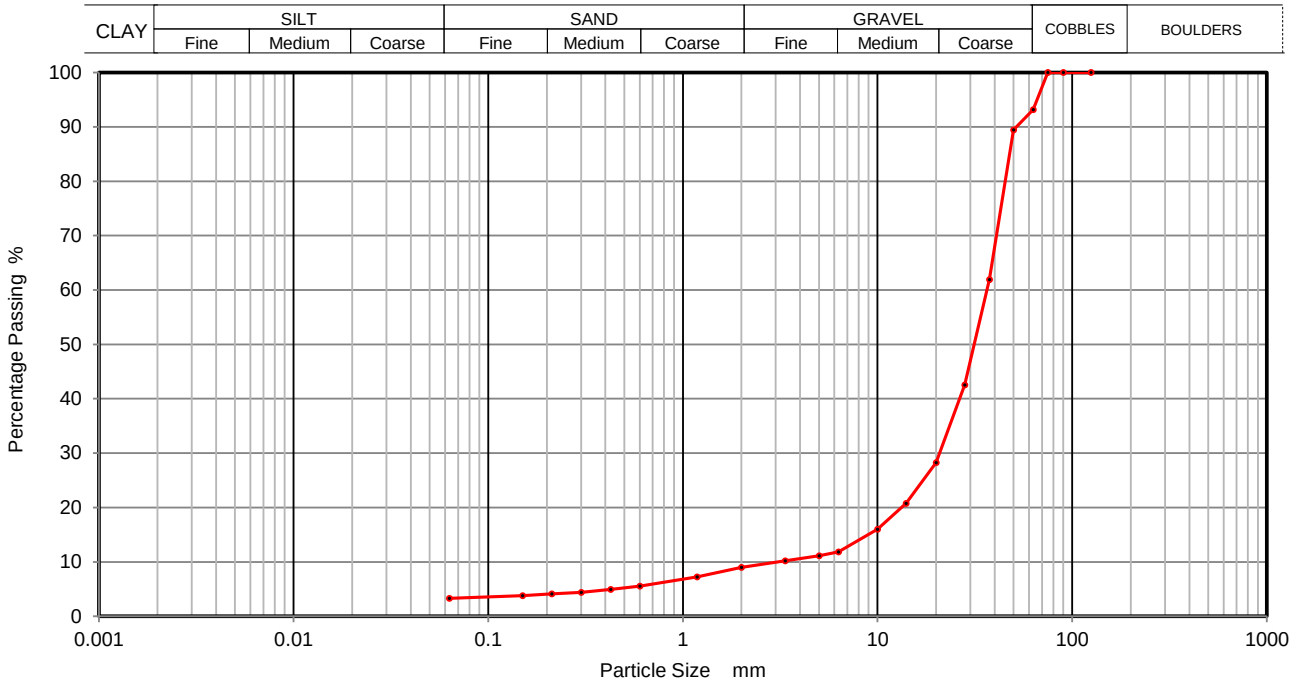
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP06
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown silty fine slightly sandy fine to coarse GRAVEL with few cobbles	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	93		
50	89		
37.5	62		
28	43		
20	28		
14	21		
10	16		
6.3	12		
5	11		
3.35	10		
2	9		
1.18	7		
0.6	6		
0.425	5		
0.3	4		
0.212	4		
0.15	4		
0.063	3		

Sample Proportions	% dry mass
Cobbles	7
Gravel	84
Sand	6
Silt and Clay	3

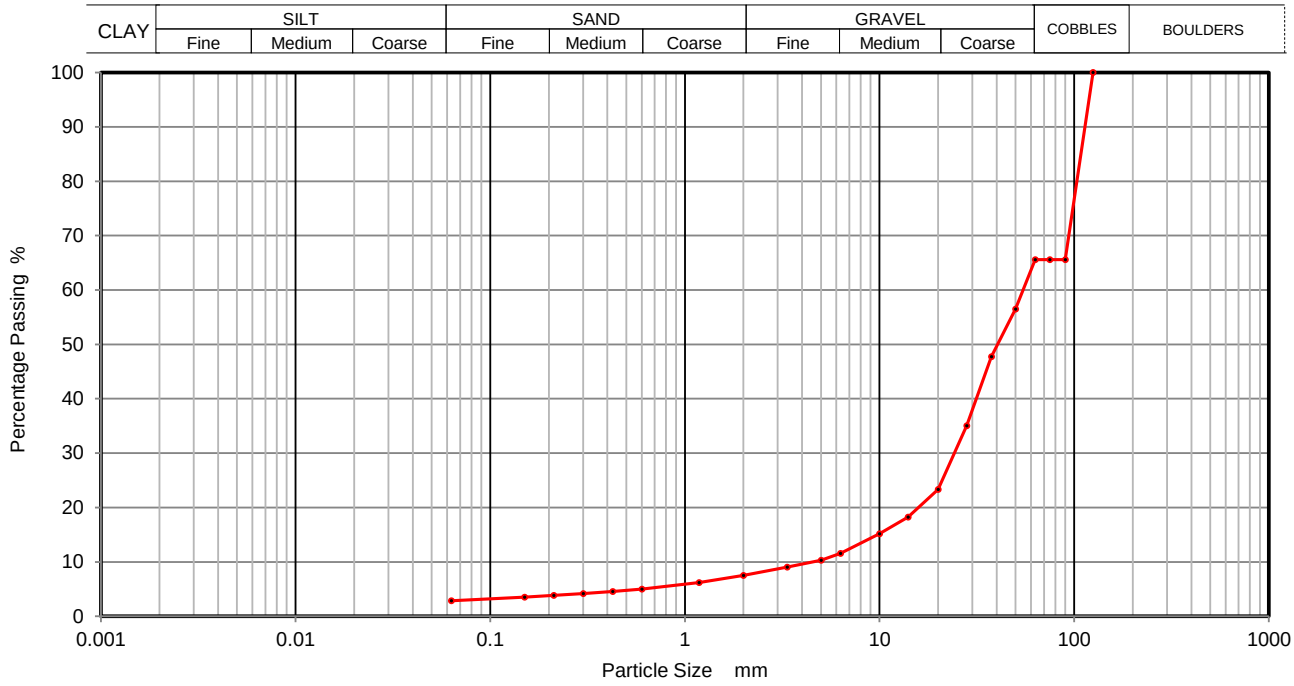
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP06
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown silty fine slightly sandy fine to coarse GRAVEL with many cobbles.	Depth Top	2.50
		Depth Base	2.70
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	66		
75	66		
63	66		
50	56		
37.5	48		
28	35		
20	23		
14	18		
10	15		
6.3	12		
5	10		
3.35	9		
2	7		
1.18	6		
0.6	5		
0.425	5		
0.3	4		
0.212	4		
0.15	4		
0.063	3		

Sample Proportions	% dry mass
Cobbles	34
Gravel	59
Sand	4
Silt and Clay	3

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

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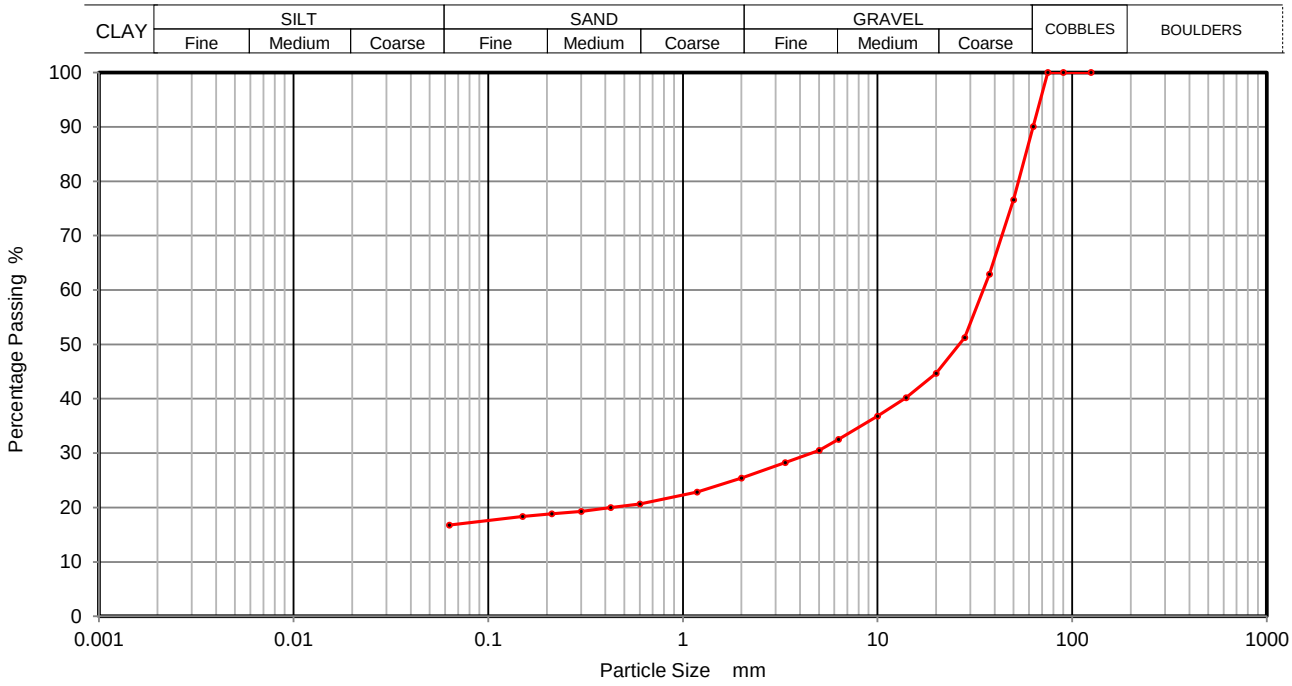
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP07
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL with many cobbles.	Depth Top	1.00
		Depth Base	1.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	90		
50	77		
37.5	63		
28	51		
20	45		
14	40		
10	37		
6.3	33		
5	31		
3.35	28		
2	25		
1.18	23		
0.6	21		
0.425	20		
0.3	19		
0.212	19		
0.15	18		
0.063	17		

Sample Proportions	% dry mass
Cobbles	10
Gravel	65
Sand	8
Silt and Clay	17

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

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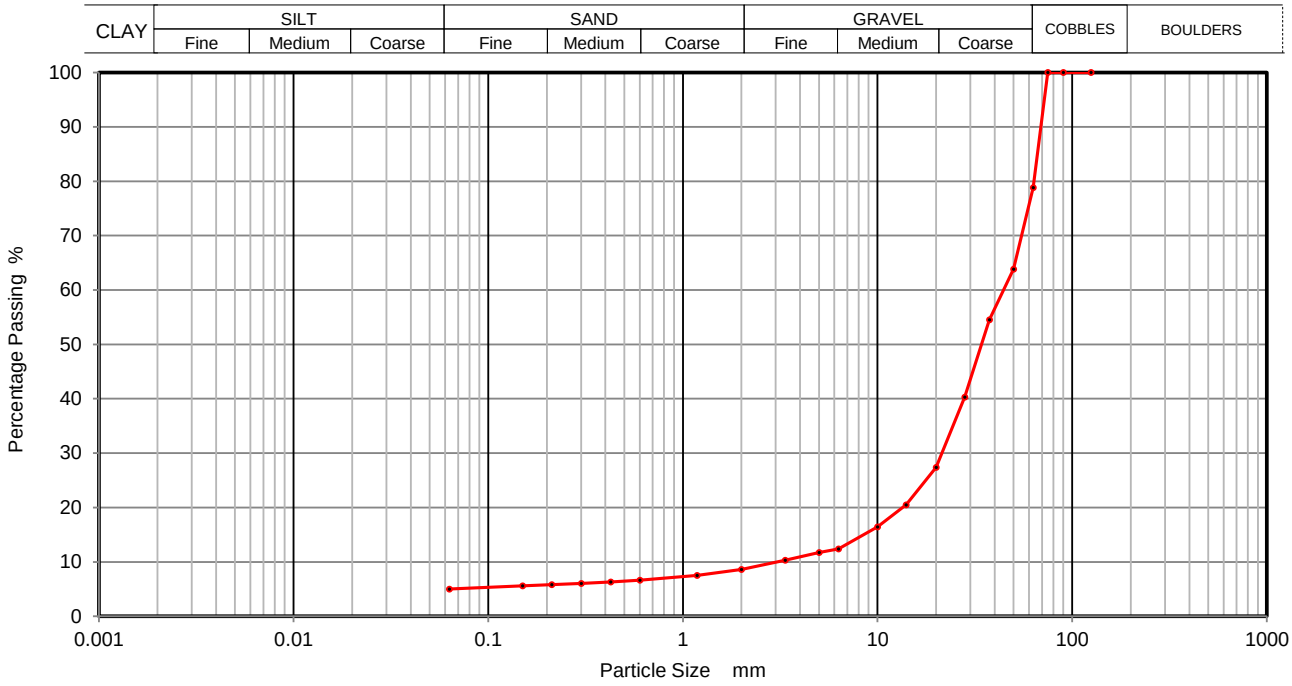
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP07
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL with many cobbles.	Depth Top	2.00
		Depth Base	2.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	79		
50	64		
37.5	55		
28	40		
20	27		
14	21		
10	16		
6.3	12		
5	12		
3.35	10		
2	9		
1.18	8		
0.6	7		
0.425	6		
0.3	6		
0.212	6		
0.15	6		
0.063	5		

Sample Proportions	% dry mass
Cobbles	21
Gravel	70
Sand	4
Silt and Clay	5

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

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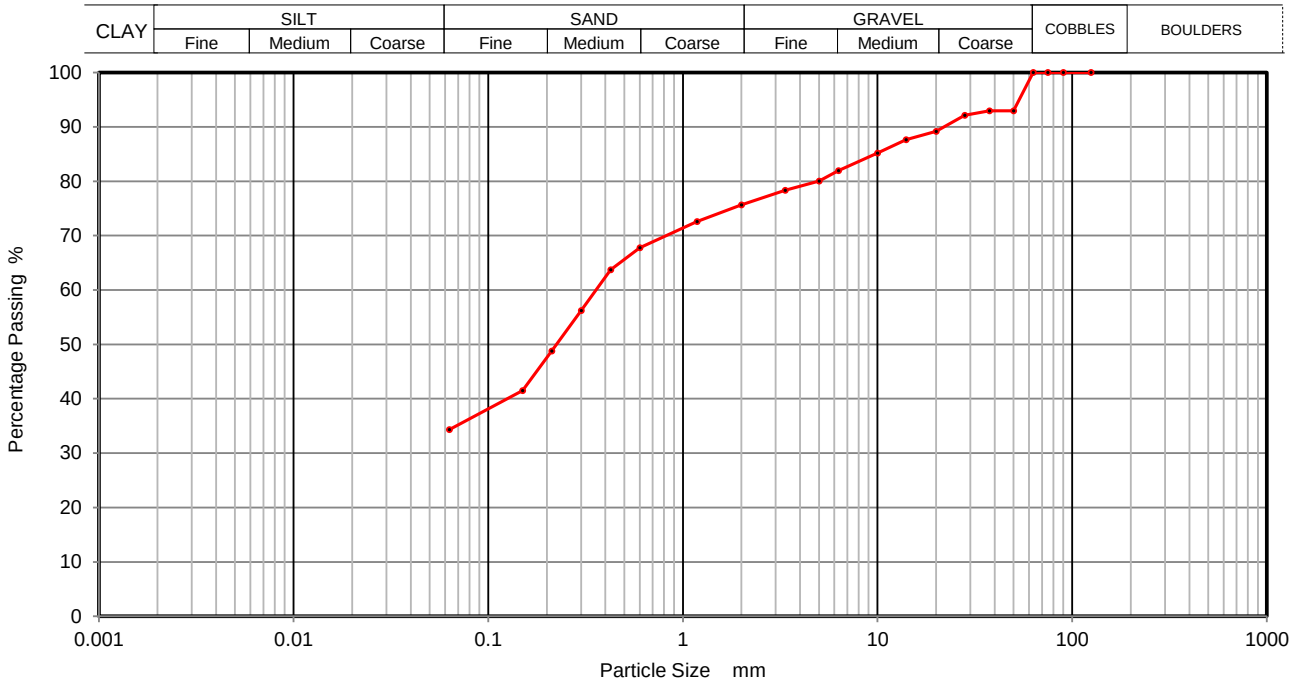
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP11
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to coarse gravelly silty clayey fine to coarse SAND.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	93		
37.5	93		
28	92		
20	89		
14	88		
10	85		
6.3	82		
5	80		
3.35	78		
2	76		
1.18	73		
0.6	68		
0.425	64		
0.3	56		
0.212	49		
0.15	42		
0.063	34		

Sample Proportions	% dry mass
Cobbles	0
Gravel	24
Sand	42
Silt and Clay	34

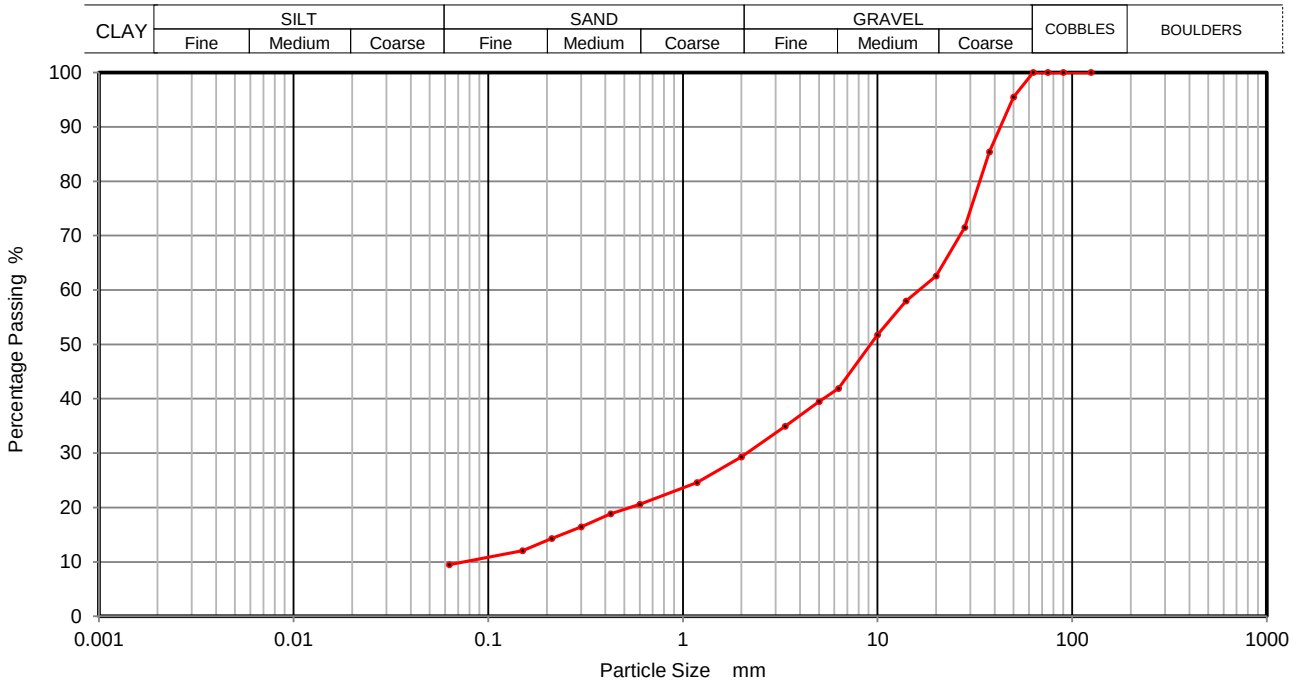
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP11
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown silty clayey fine to coarse sandy fine to coarse GRAVEL.	Depth Top	2.50
		Depth Base	3.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	95		
37.5	85		
28	71		
20	63		
14	58		
10	52		
6.3	42		
5	39		
3.35	35		
2	29		
1.18	25		
0.6	21		
0.425	19		
0.3	16		
0.212	14		
0.15	12		
0.063	9		

Sample Proportions	% dry mass
Cobbles	0
Gravel	71
Sand	20
Silt and Clay	9

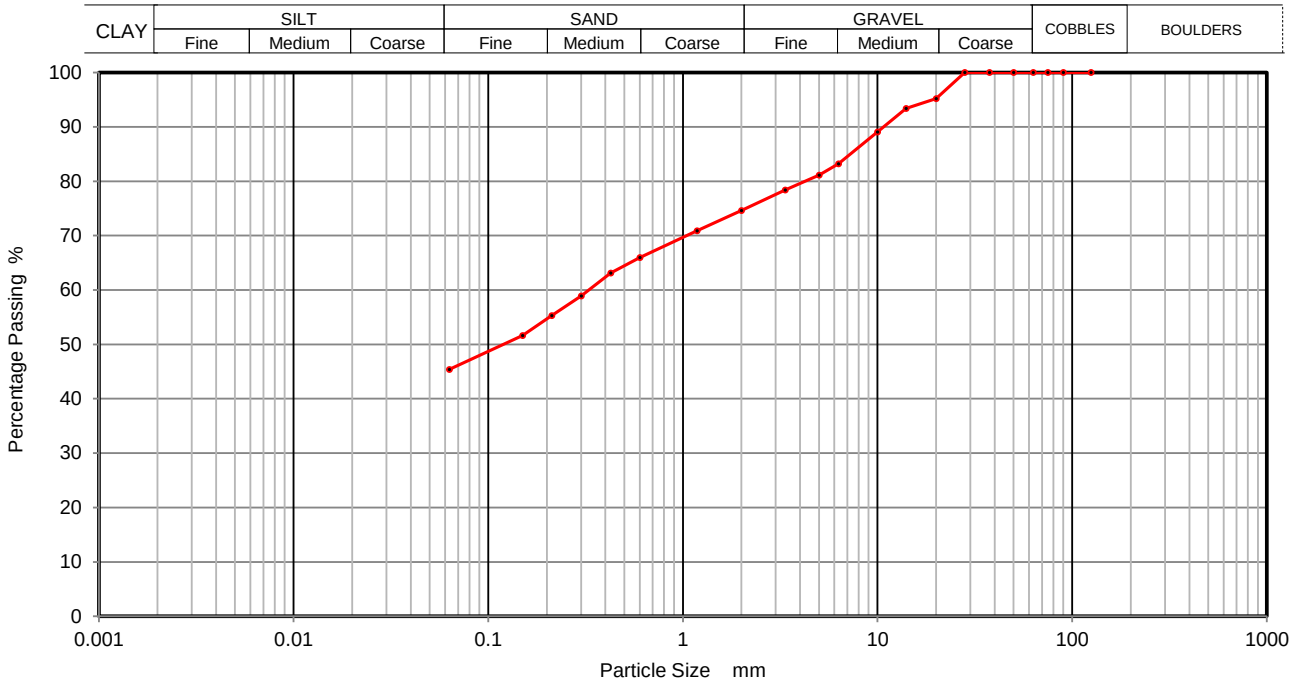
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP12
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine to coarse gravelly fine to coarse sandy silty CLAY.	Depth Top	1.10
		Depth Base	1.20
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	95		
14	93		
10	89		
6.3	83		
5	81		
3.35	78		
2	75		
1.18	71		
0.6	66		
0.425	63		
0.3	59		
0.212	55		
0.15	52		
0.063	45		

Sample Proportions	% dry mass
Cobbles	0
Gravel	25
Sand	30
Silt and Clay	45

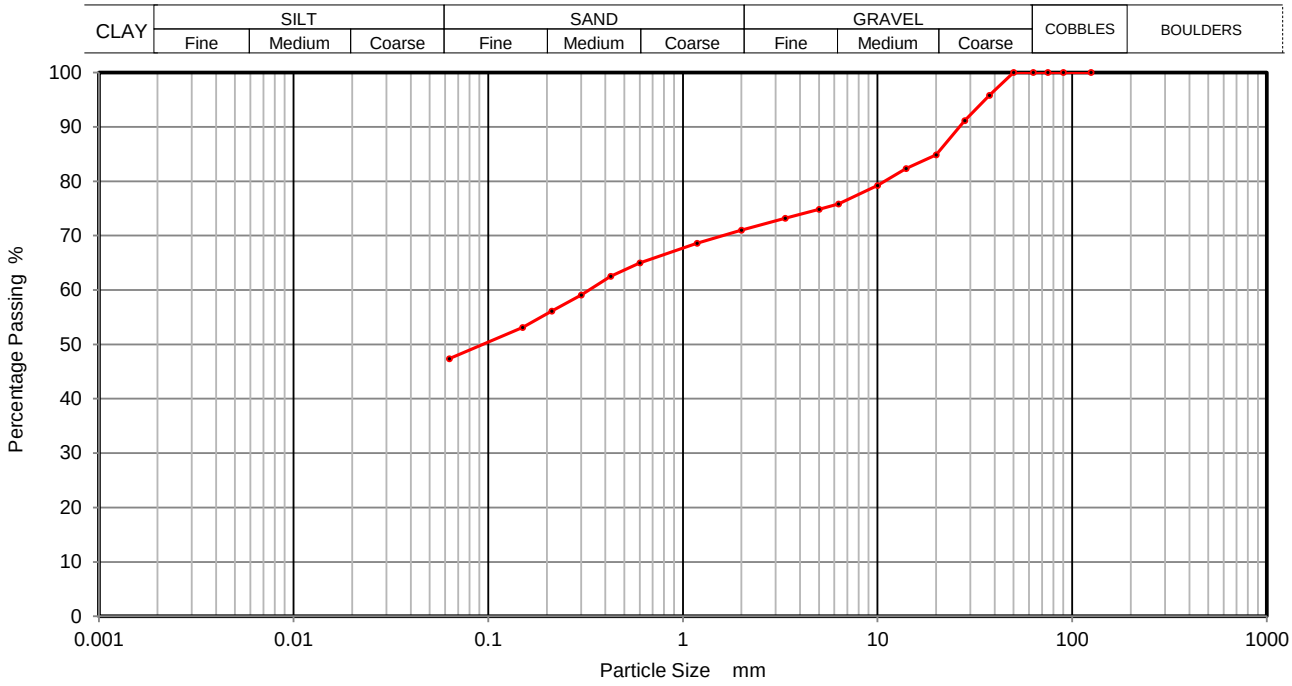
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP12
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine to coarse sandy fine to coarse gravelly silty CLAY.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	96		
28	91		
20	85		
14	82		
10	79		
6.3	76		
5	75		
3.35	73		
2	71		
1.18	69		
0.6	65		
0.425	63		
0.3	59		
0.212	56		
0.15	53		
0.063	47		

Sample Proportions	% dry mass
Cobbles	0
Gravel	29
Sand	24
Silt and Clay	47

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
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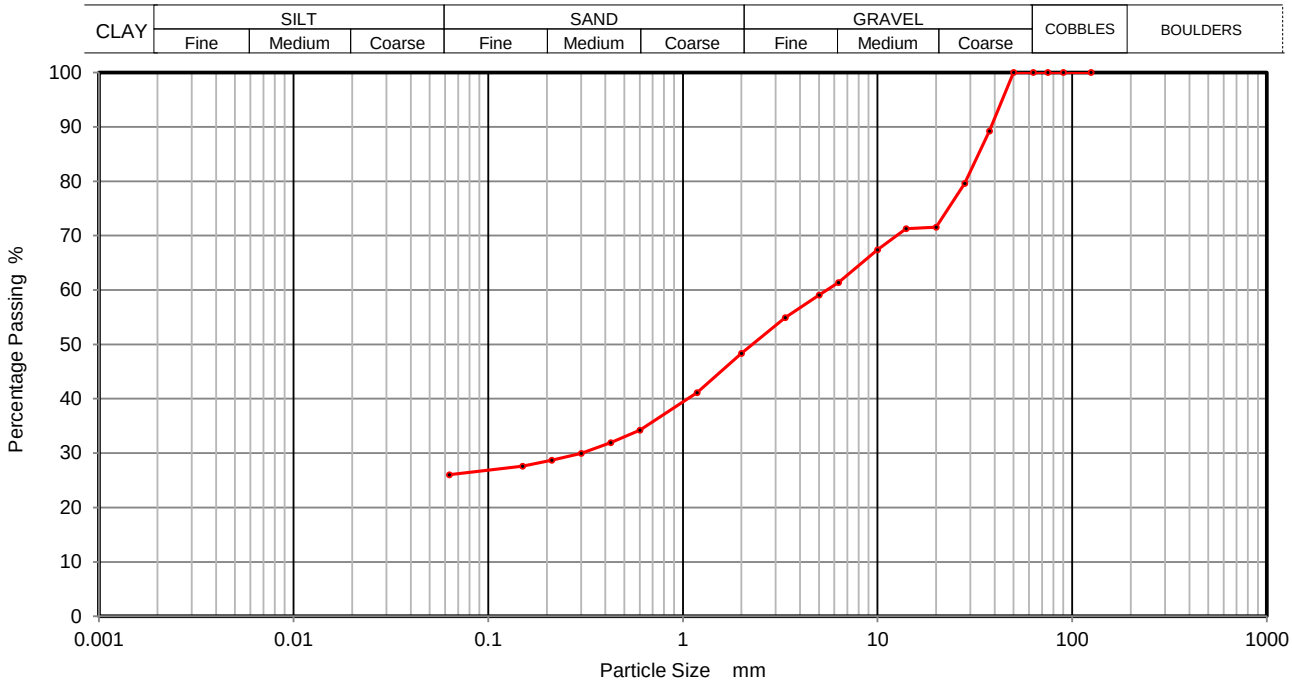
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP13
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine to coarse sandy silty clayey fine to coarse GRAVEL.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	89		
28	80		
20	72		
14	71		
10	67		
6.3	61		
5	59		
3.35	55		
2	48		
1.18	41		
0.6	34		
0.425	32		
0.3	30		
0.212	29		
0.15	28		
0.063	26		

Sample Proportions	% dry mass
Cobbles	0
Gravel	52
Sand	22
Silt and Clay	26

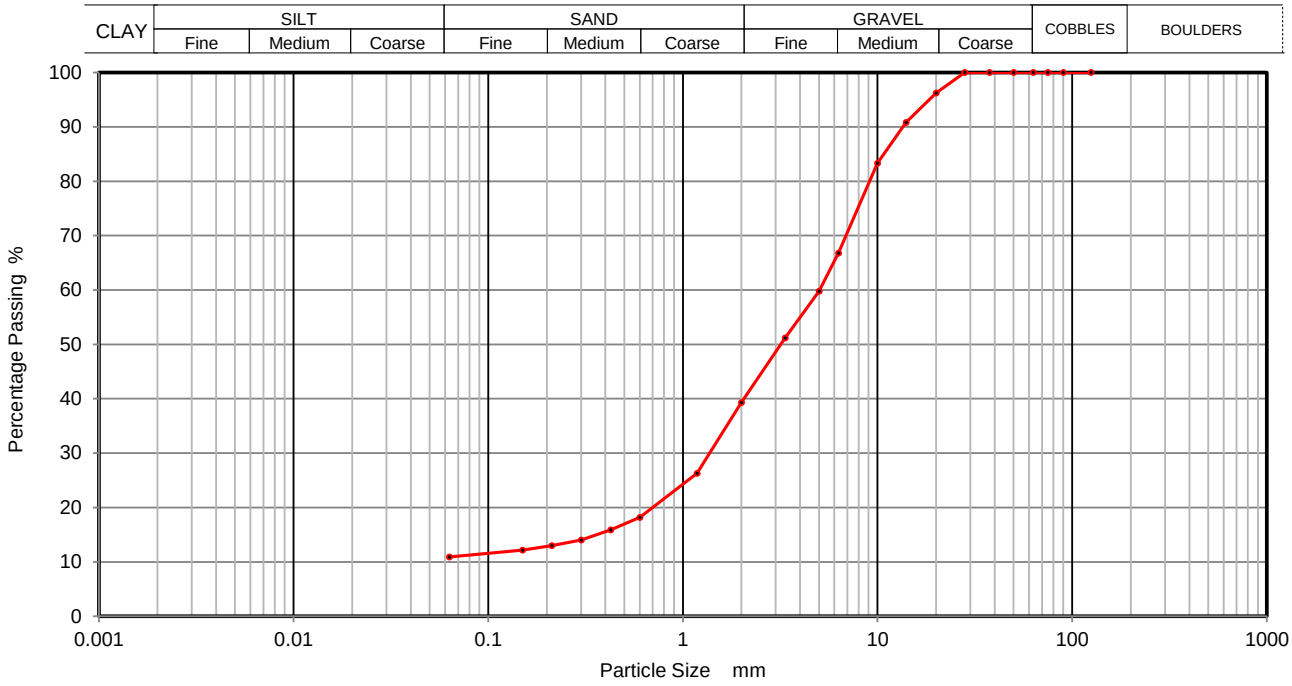
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP13
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown silty fine to coarse sandy fine to coarse GRAVEL.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	96		
14	91		
10	83		
6.3	67		
5	60		
3.35	51		
2	39		
1.18	26		
0.6	18		
0.425	16		
0.3	14		
0.212	13		
0.15	12		
0.063	11		

Sample Proportions	% dry mass
Cobbles	0
Gravel	61
Sand	28
Silt and Clay	11

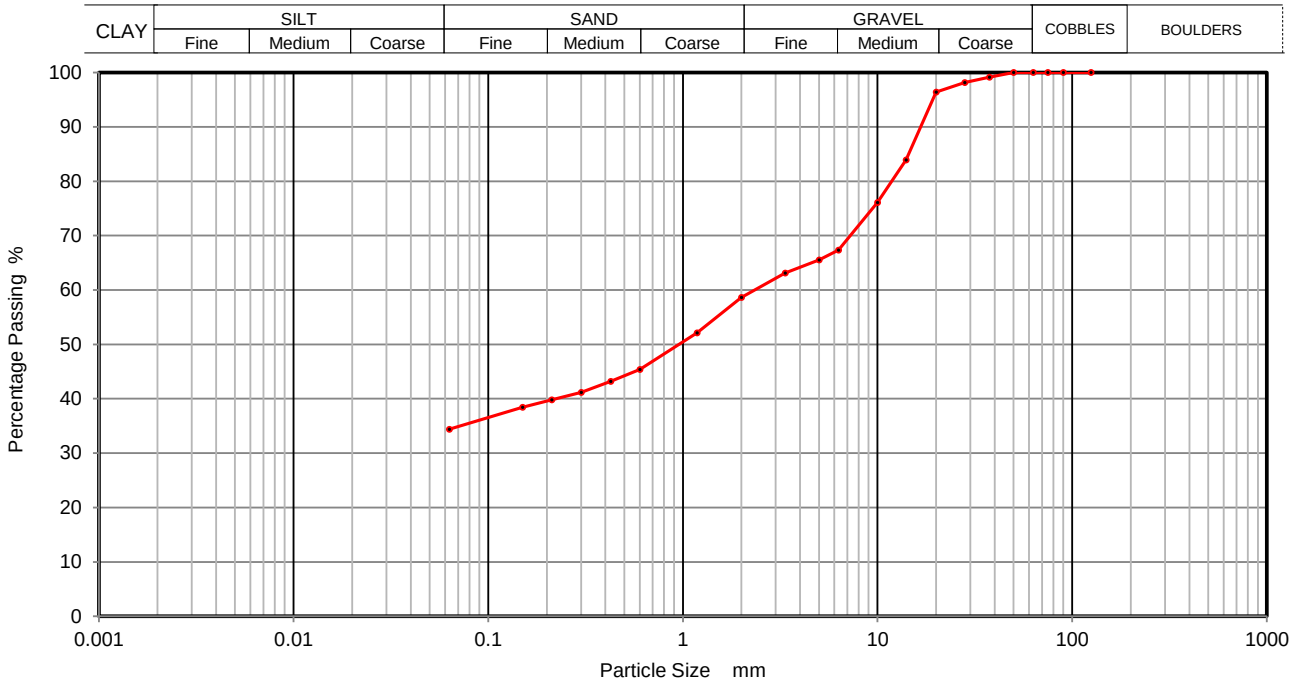
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP14
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine to coarse sandy silty clayey fine to coarse GRAVEL.	Depth Top	0.50
		Depth Base	0.70
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	99		
28	98		
20	96		
14	84		
10	76		
6.3	67		
5	66		
3.35	63		
2	59		
1.18	52		
0.6	45		
0.425	43		
0.3	41		
0.212	40		
0.15	38		
0.063	34		

Sample Proportions	% dry mass
Cobbles	0
Gravel	41
Sand	25
Silt and Clay	34

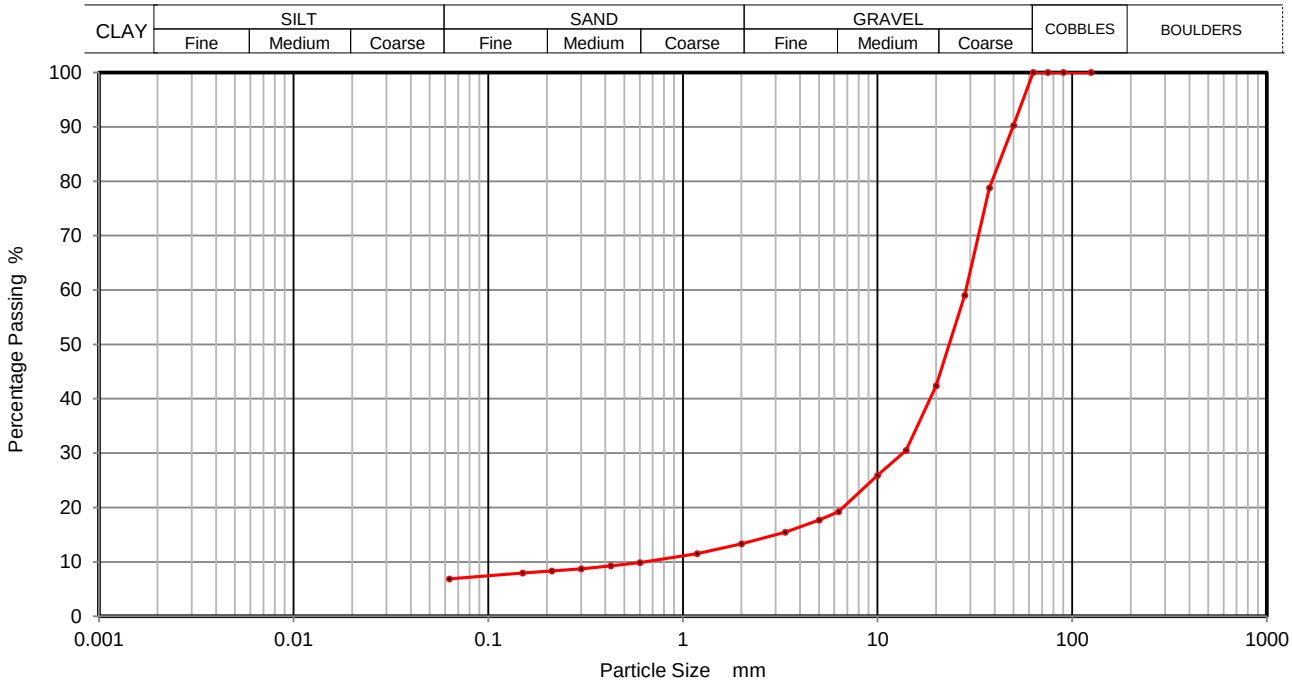
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP14
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL.	Depth Top	1.00
		Depth Base	1.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	90		
37.5	79		
28	59		
20	42		
14	30		
10	26		
6.3	19		
5	18		
3.35	15		
2	13		
1.18	11		
0.6	10		
0.425	9		
0.3	9		
0.212	8		
0.15	8		
0.063	7		

Sample Proportions	% dry mass
Cobbles	0
Gravel	87
Sand	6
Silt and Clay	7

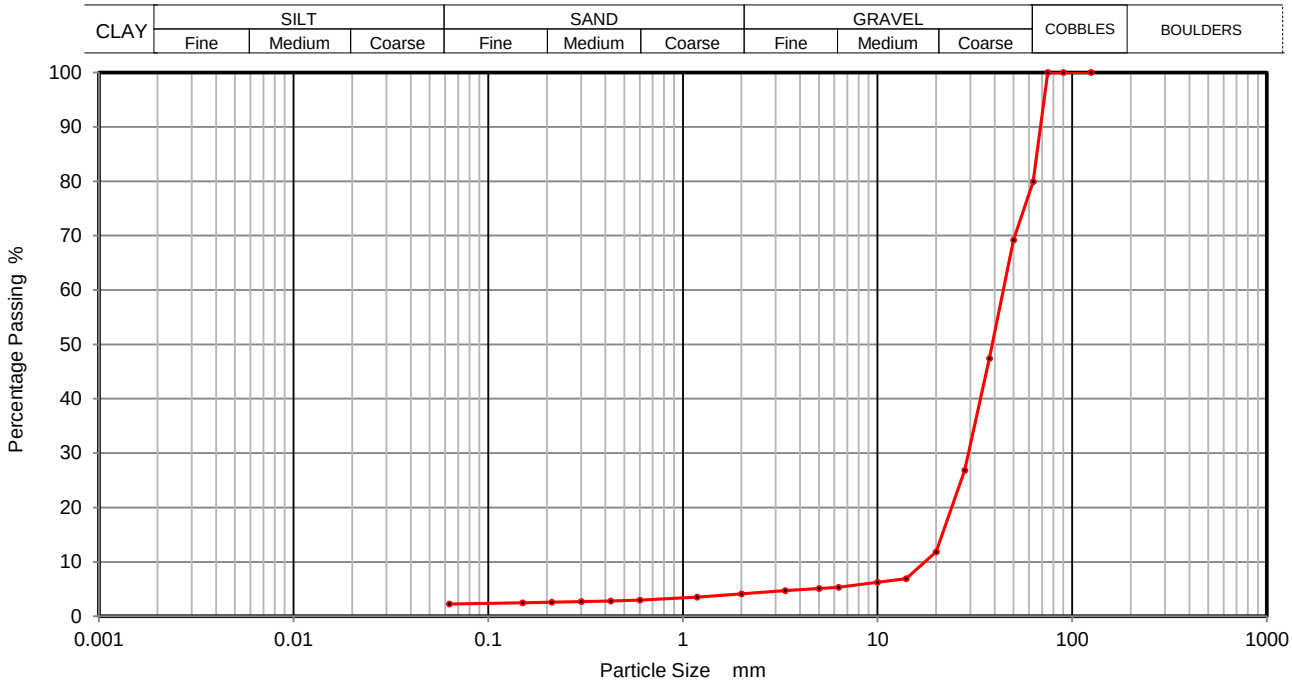
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP14
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL with many cobbles.	Depth Top	2.20
		Depth Base	2.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	80		
50	69		
37.5	47		
28	27		
20	12		
14	7		
10	6		
6.3	5		
5	5		
3.35	5		
2	4		
1.18	3		
0.6	3		
0.425	3		
0.3	3		
0.212	3		
0.15	2		
0.063	2		

Sample Proportions	% dry mass
Cobbles	20
Gravel	76
Sand	2
Silt and Clay	2

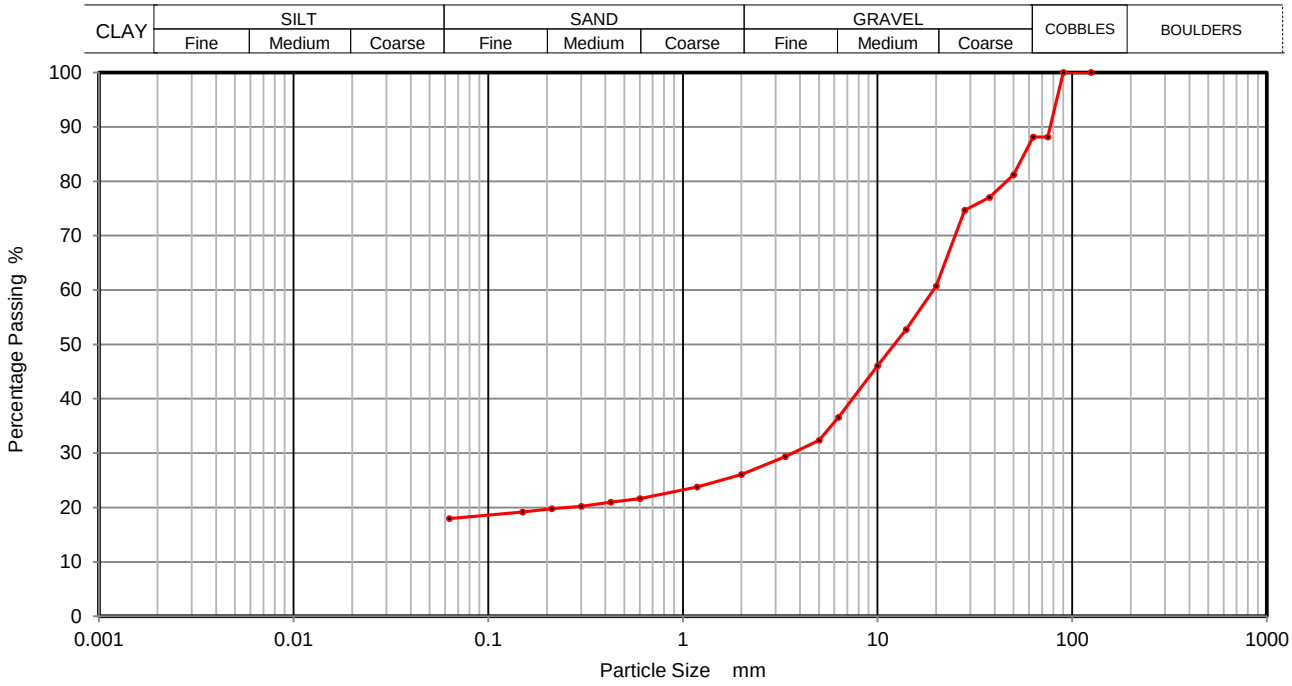
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP15
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL with many cobbles.	Depth Top	0.50
		Depth Base	1.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	88		
63	88		
50	81		
37.5	77		
28	75		
20	61		
14	53		
10	46		
6.3	37		
5	32		
3.35	29		
2	26		
1.18	24		
0.6	22		
0.425	21		
0.3	20		
0.212	20		
0.15	19		
0.063	18		

Sample Proportions	% dry mass
Cobbles	12
Gravel	62
Sand	8
Silt and Clay	18

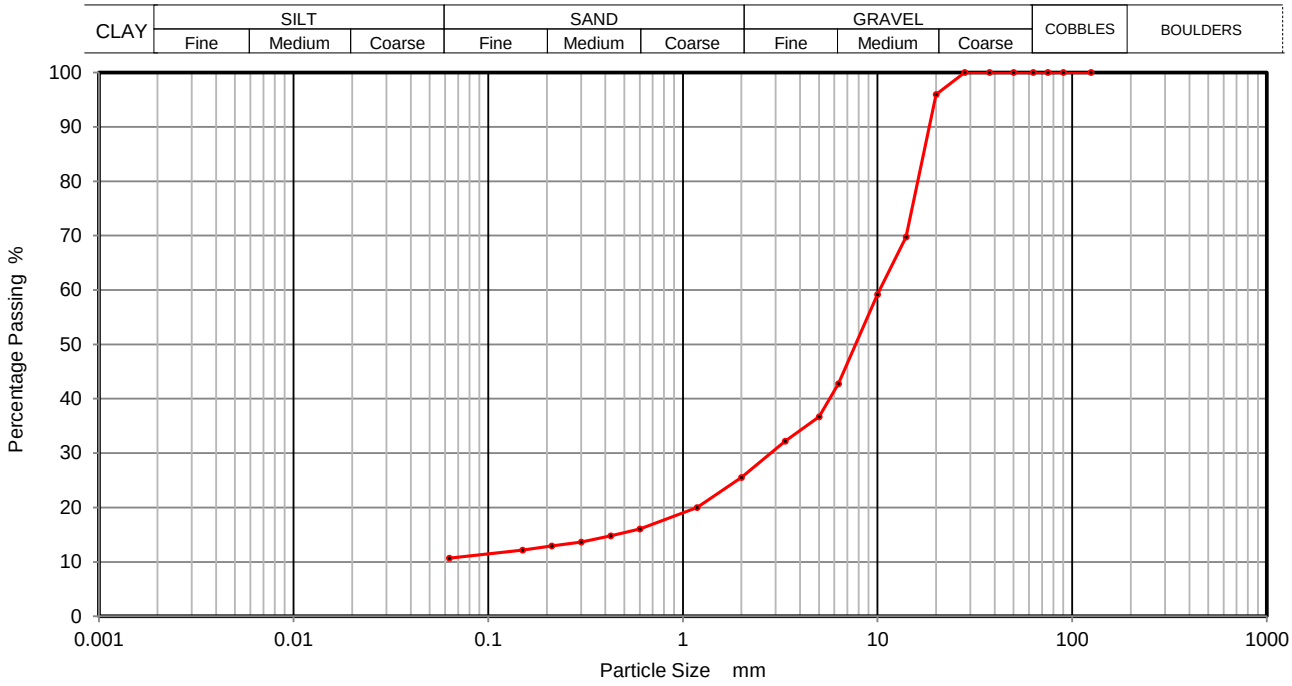
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP15
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown silty clayey fine to medium sandy fine to coarse GRAVEL.	Depth Top	1.50
		Depth Base	1.70
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	96		
14	70		
10	59		
6.3	43		
5	37		
3.35	32		
2	26		
1.18	20		
0.6	16		
0.425	15		
0.3	14		
0.212	13		
0.15	12		
0.063	11		

Sample Proportions	% dry mass
Cobbles	0
Gravel	74
Sand	15
Silt and Clay	11

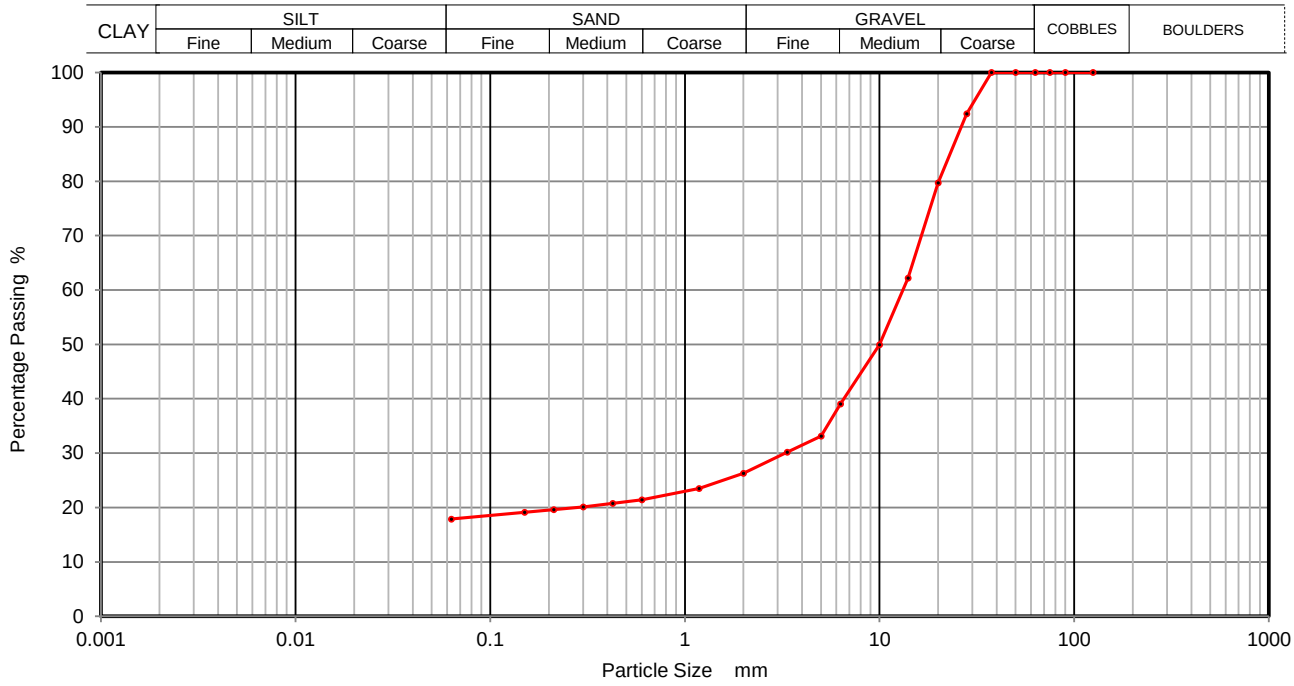
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP18
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine sandy silty clayey fine to coarse GRAVEL containing shale.	Depth Top	0.50
		Depth Base	0.90
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	92		
20	80		
14	62		
10	50		
6.3	39		
5	33		
3.35	30		
2	26		
1.18	23		
0.6	21		
0.425	21		
0.3	20		
0.212	20		
0.15	19		
0.063	18		

Sample Proportions	% dry mass
Cobbles	0
Gravel	74
Sand	8
Silt and Clay	18

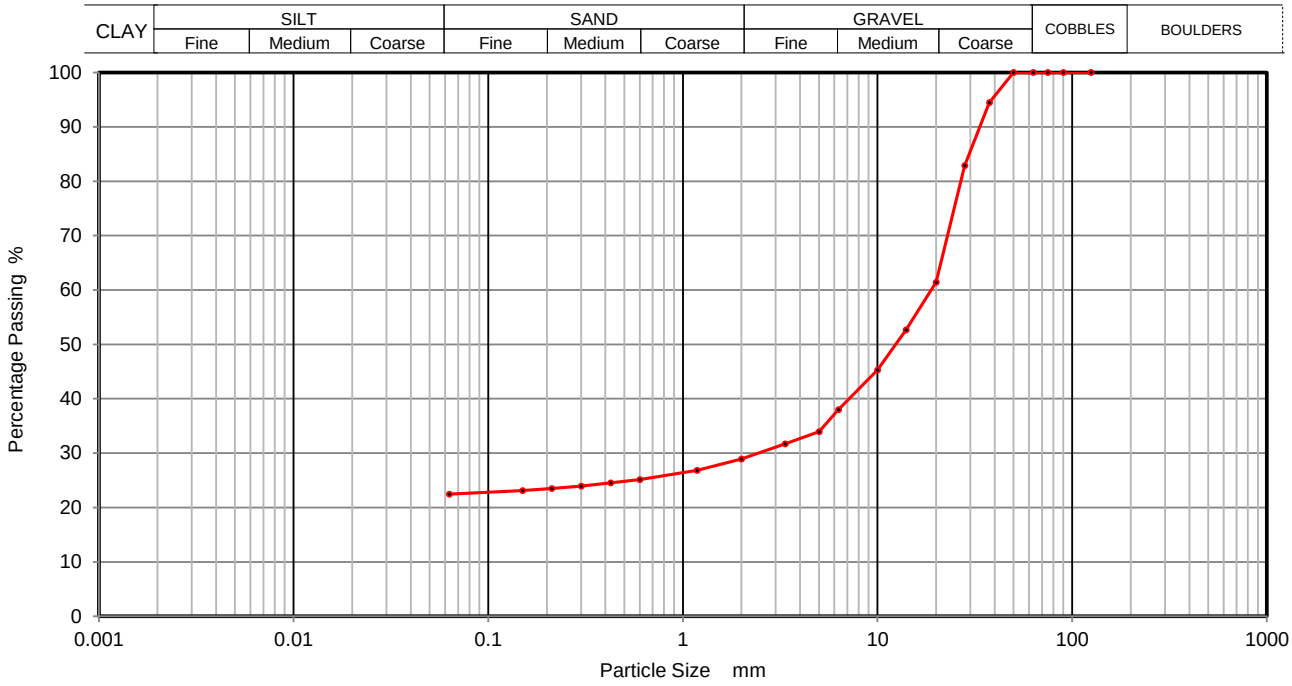
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP18
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL containing shale.	Depth Top	1.50
		Depth Base	2.00
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	95		
28	83		
20	61		
14	53		
10	45		
6.3	38		
5	34		
3.35	32		
2	29		
1.18	27		
0.6	25		
0.425	25		
0.3	24		
0.212	23		
0.15	23		
0.063	22		

Sample Proportions	% dry mass
Cobbles	0
Gravel	71
Sand	7
Silt and Clay	22

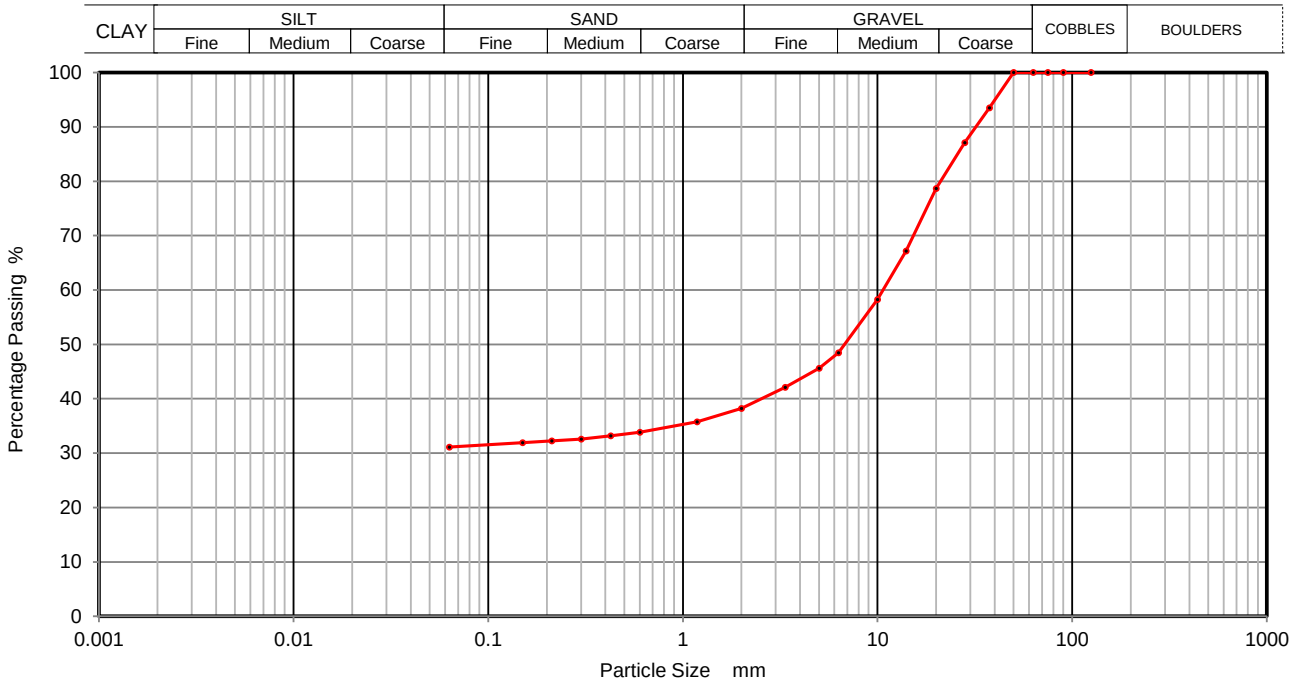
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP19
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine slightly sandy silty clayey fine to coarse GRAVEL.	Depth Top	0.60
		Depth Base	0.70
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	94		
28	87		
20	79		
14	67		
10	58		
6.3	48		
5	46		
3.35	42		
2	38		
1.18	36		
0.6	34		
0.425	33		
0.3	33		
0.212	32		
0.15	32		
0.063	31		

Sample Proportions	% dry mass
Cobbles	0
Gravel	62
Sand	7
Silt and Clay	31

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
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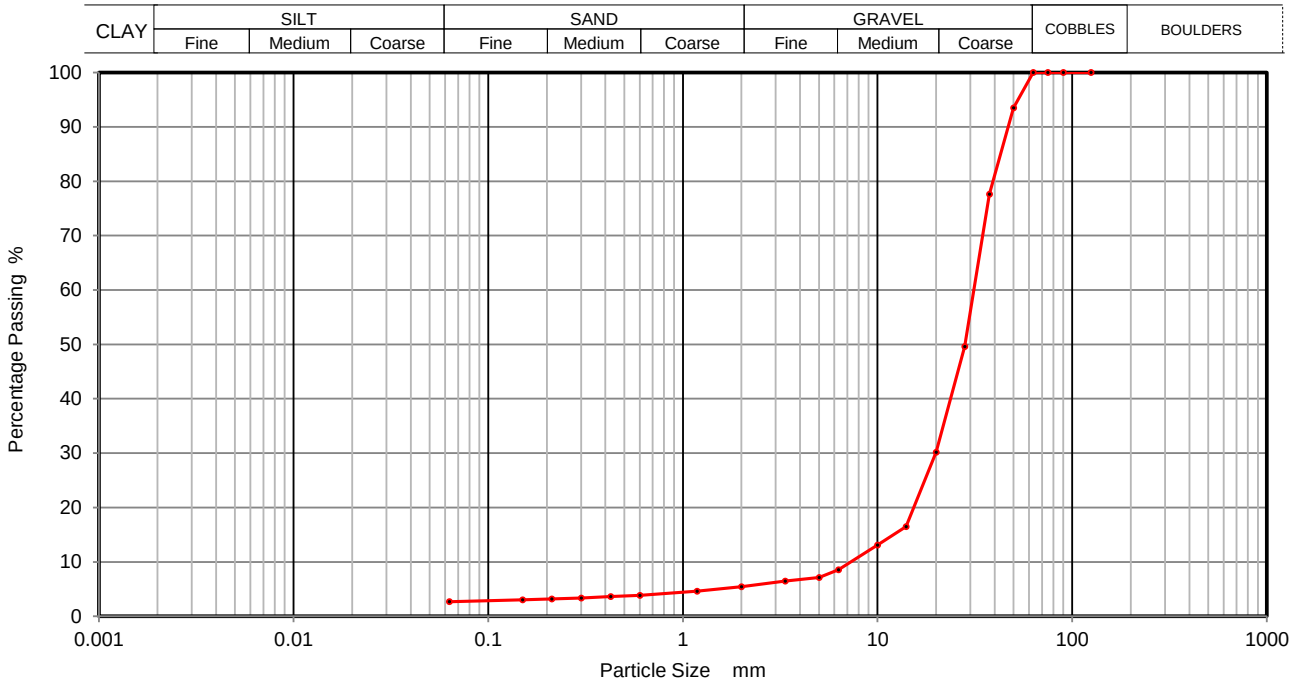
GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46614
		Borehole/Pit No.	RCE-TP19
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine slightly sandy silty fine to coarse GRAVEL.	Depth Top	1.00
		Depth Base	1.50
Date Tested	14/11/2019	Sample Type	B



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	93		
37.5	78		
28	50		
20	30		
14	16		
10	13		
6.3	9		
5	7		
3.35	6		
2	5		
1.18	5		
0.6	4		
0.425	4		
0.3	3		
0.212	3		
0.15	3		
0.063	3		

Sample Proportions	% dry mass
Cobbles	0
Gravel	95
Sand	2
Silt and Clay	3

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	11/12/2019	Paul Evans	P Evans

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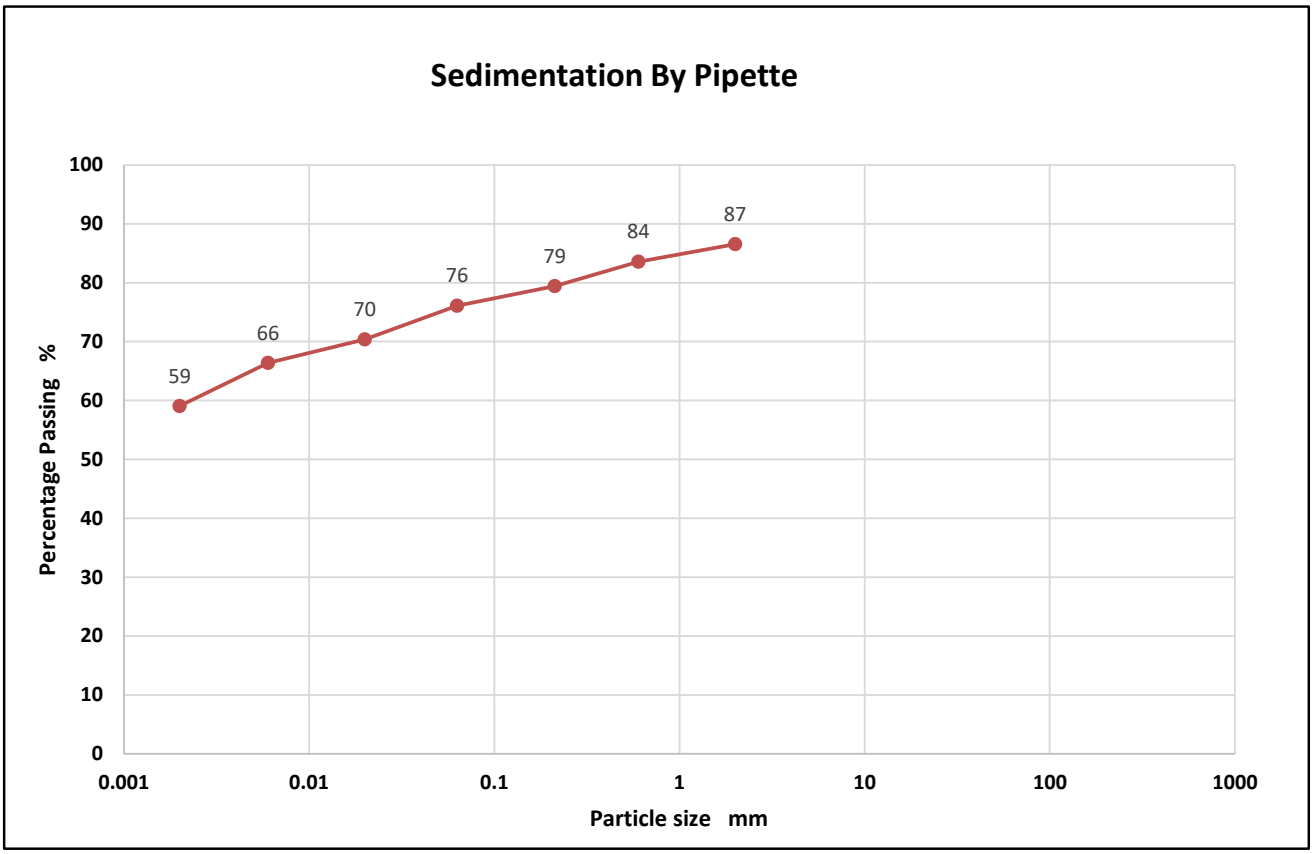
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH1
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown sandy fine to medium gravelly silty CLAY	Depth Top	0.40
		Depth Base	1.00
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	87
0.60	84
0.212	79
0.063	76

Sedimentation Analysis

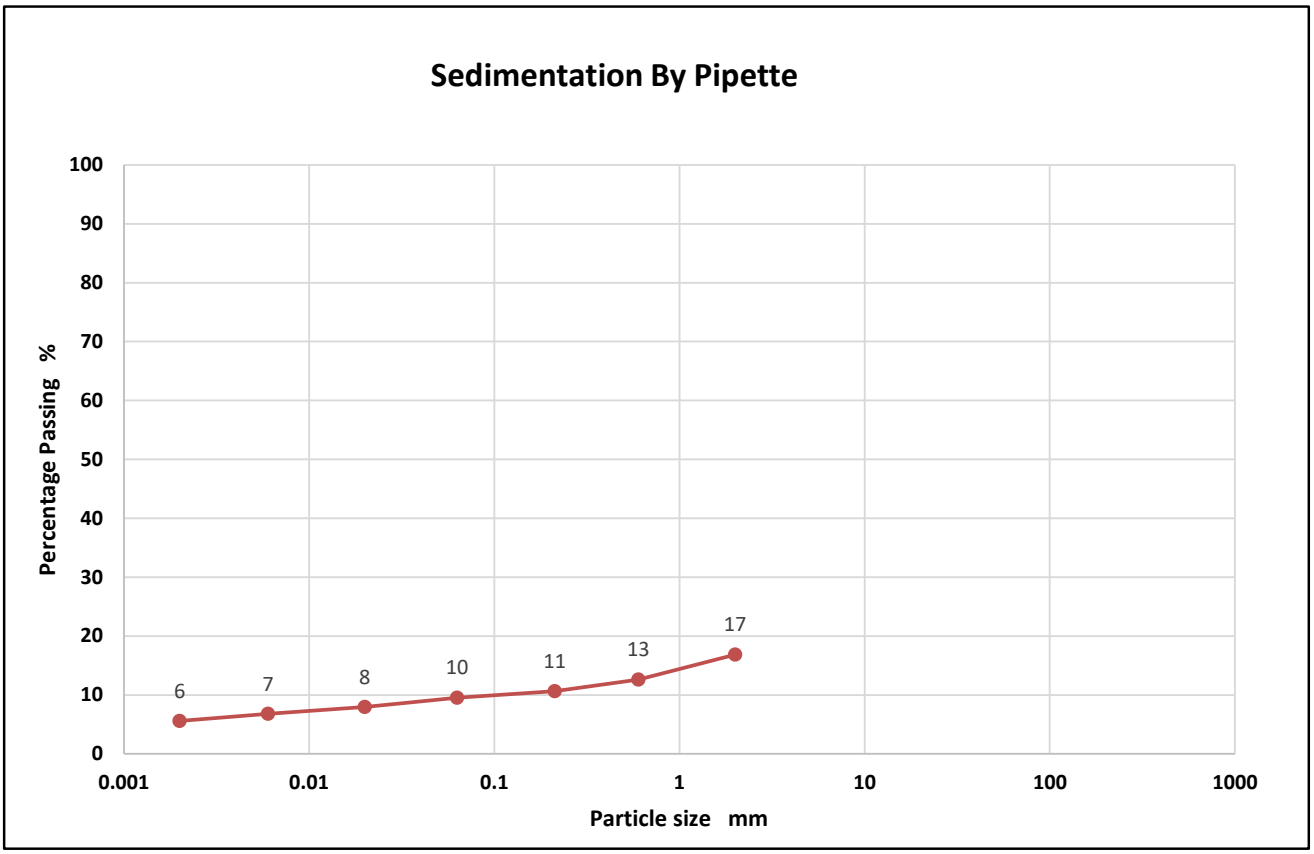
Particle Diameter	Percentage Passing
0.02	70
0.006	66
0.002	59

Soil Fraction	Total Percentage
Gravel	13
Sand	10
Silt	17
Clay	59

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH4
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown sandy, clayey fine to coarse GRAVEL	Depth Top	1.20
		Depth Base	1.50
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	17
0.60	13
0.212	11
0.063	10

Sedimentation Analysis

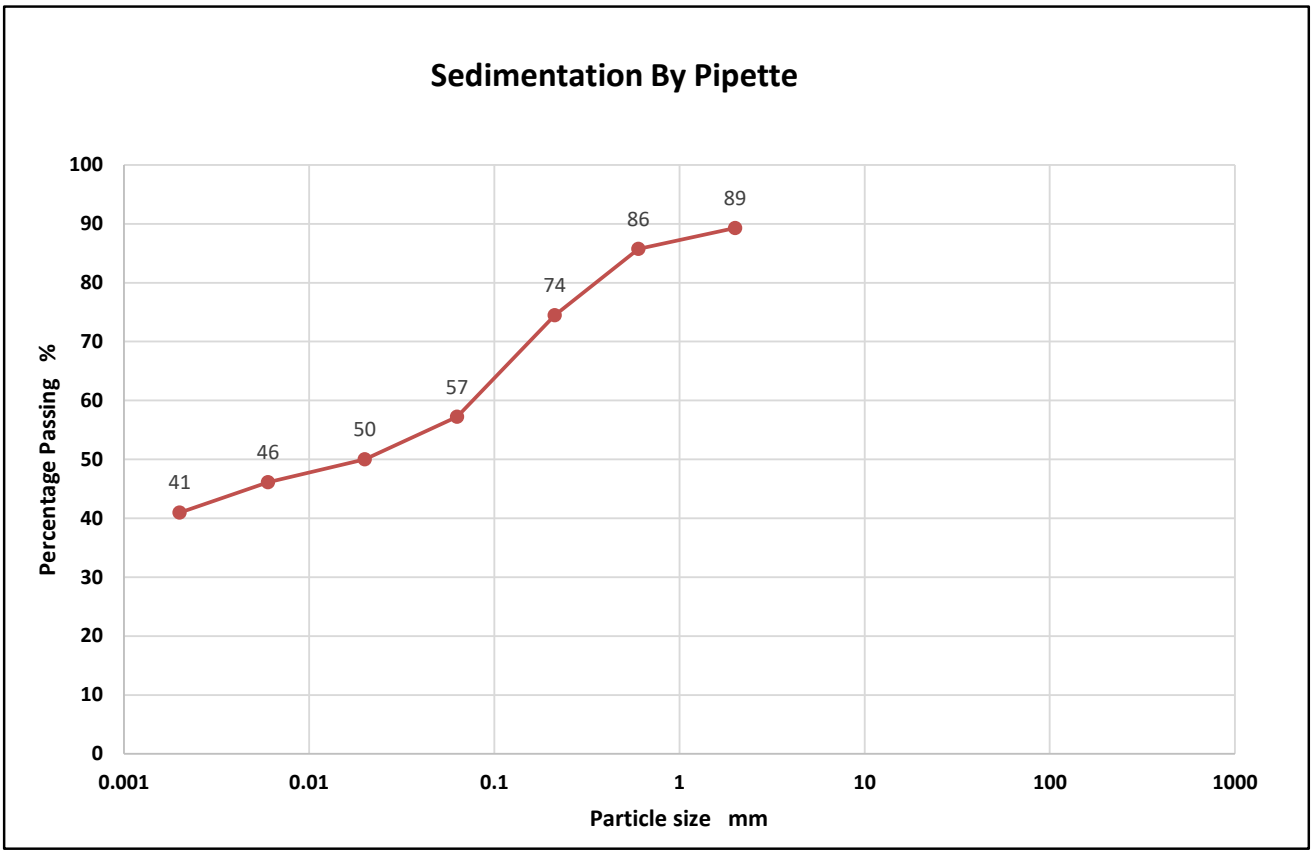
Particle Diameter	Percentage Passing
0.02	8
0.006	7
0.002	6

Soil Fraction	Total Percentage
Gravel	83
Sand	7
Silt	4
Clay	6

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH5
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to medium gravelly, silty, sandy CLAY	Depth Top	1.65
		Depth Base	1.70
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	89
0.60	86
0.212	74
0.063	57

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	50
0.006	46
0.002	41

Soil Fraction	Total Percentage
Gravel	11
Sand	32
Silt	16
Clay	41

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

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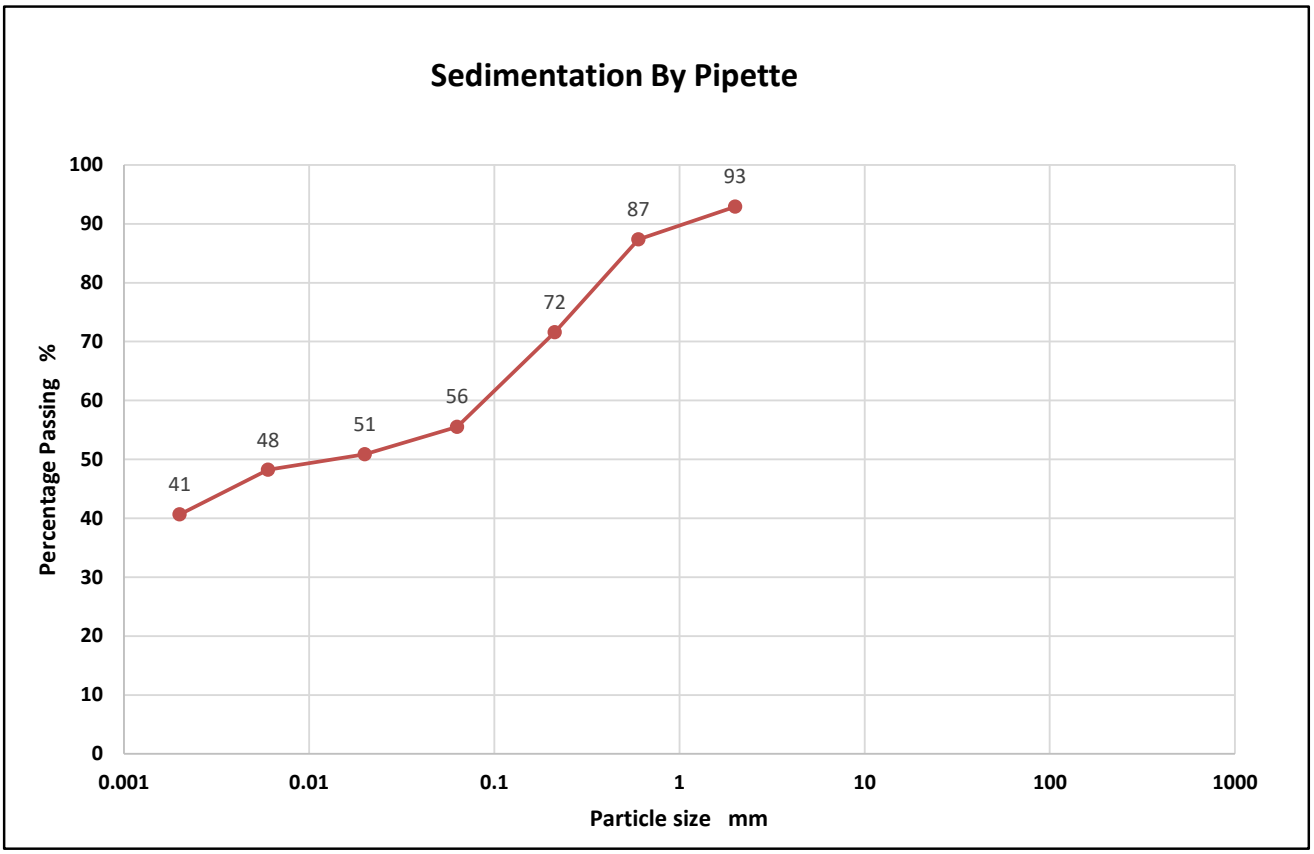
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH5
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine to medium gravelly, silty, sandy CLAY	Depth Top	2.45
		Depth Base	2.50
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	93
0.60	87
0.212	72
0.063	56

Sedimentation Analysis

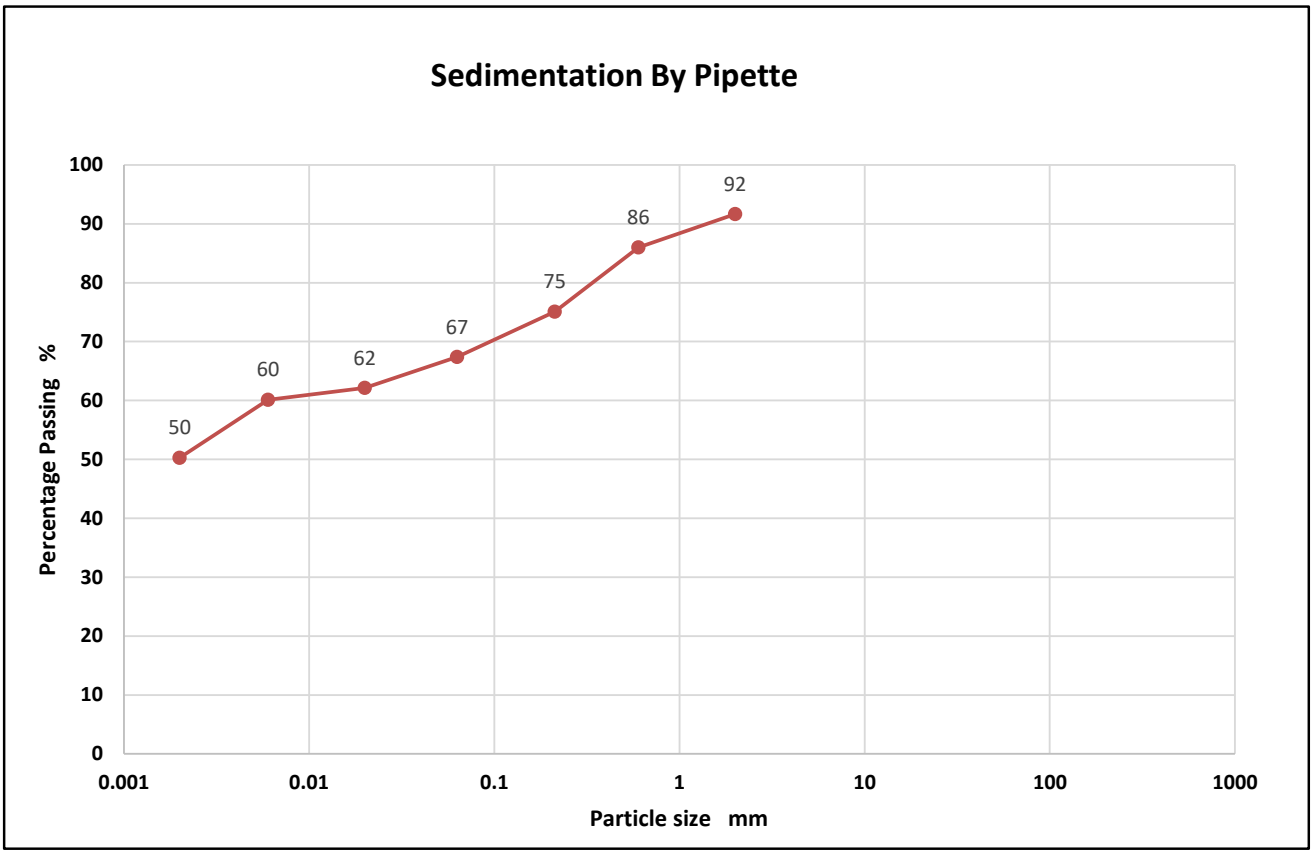
Particle Diameter	Percentage Passing
0.02	51
0.006	48
0.002	41

Soil Fraction	Total Percentage
Gravel	7
Sand	37
Silt	15
Clay	41

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH5
Site Name	A40 RCE	Sample No.	13
Soil Description	Brown fine to medium gravelly, silty, sandy CLAY	Depth Top	3.45
		Depth Base	3.50
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	92
0.60	86
0.212	75
0.063	67

Sedimentation Analysis

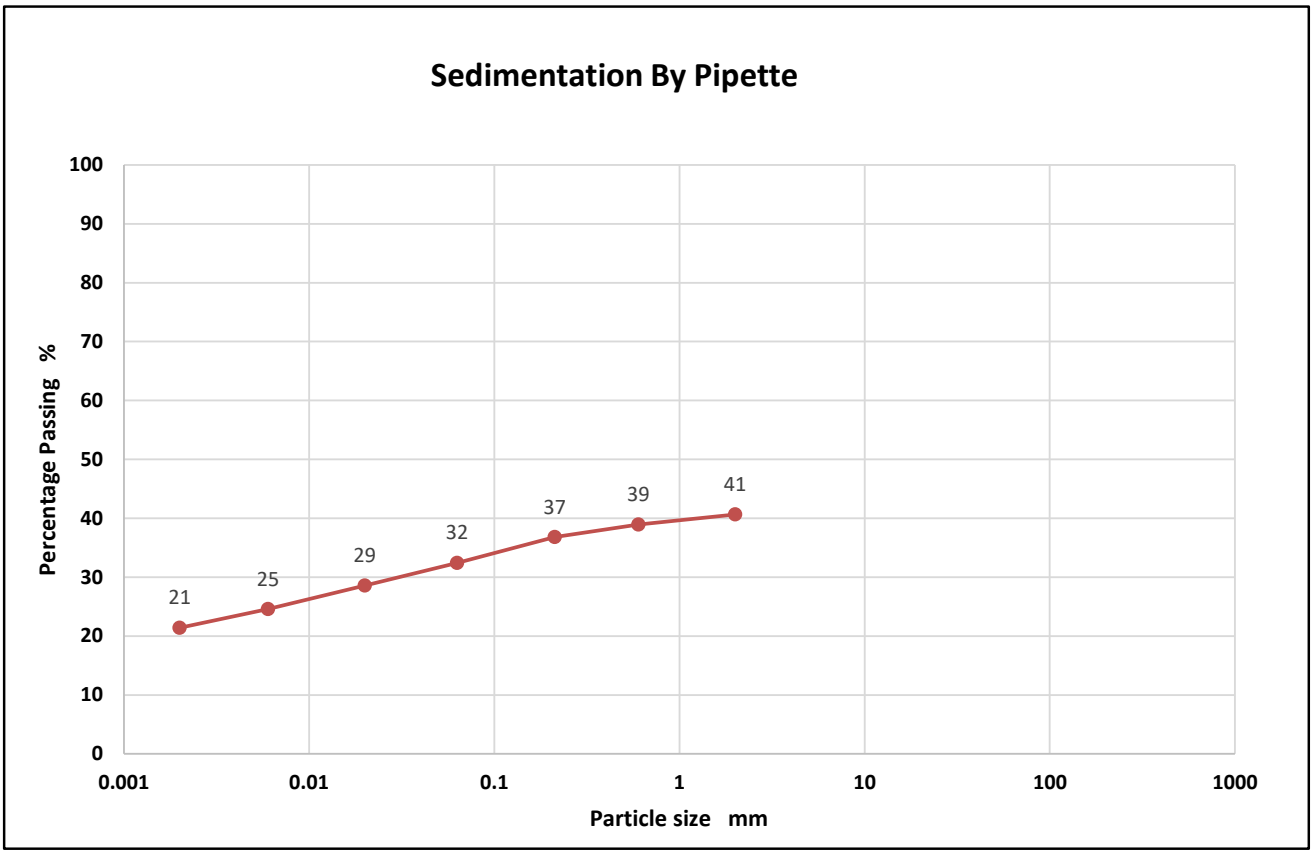
Particle Diameter	Percentage Passing
0.02	62
0.006	60
0.002	50

Soil Fraction	Total Percentage
Gravel	8
Sand	24
Silt	17
Clay	50

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH5
Site Name	A40 RCE	Sample No.	20
Soil Description	Dark brown slightly sandy, silty, clayey, fine to medium GRAVEL	Depth Top	5.45
		Depth Base	5.50
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	41
0.60	39
0.212	37
0.063	32

Sedimentation Analysis

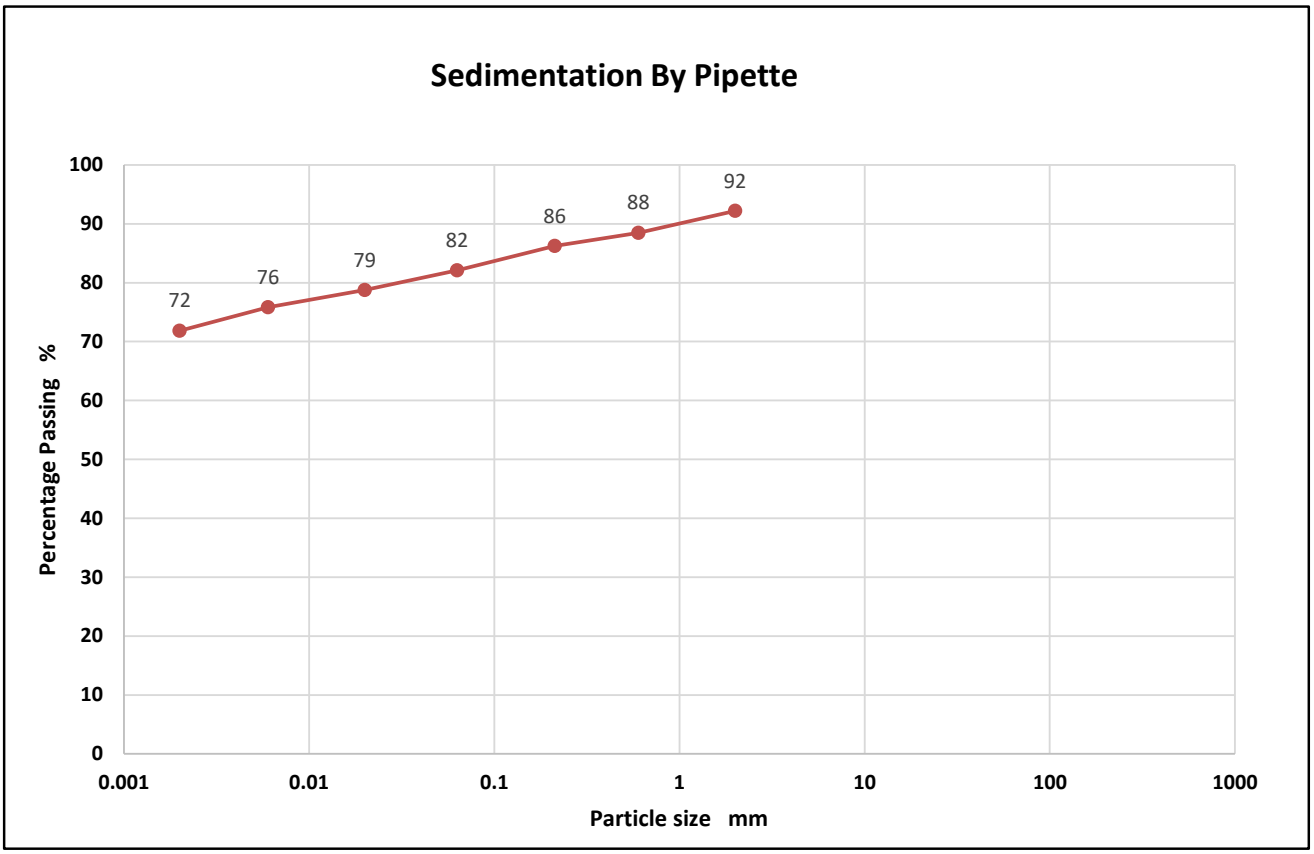
Particle Diameter	Percentage Passing
0.02	29
0.006	25
0.002	21

Soil Fraction	Total Percentage
Gravel	59
Sand	8
Silt	11
Clay	21

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH5
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown silty, sandy,slightly fine to medium gravelly CLAY	Depth Top	4.5m
		Depth Base	
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	92
0.60	88
0.212	86
0.063	82

Sedimentation Analysis

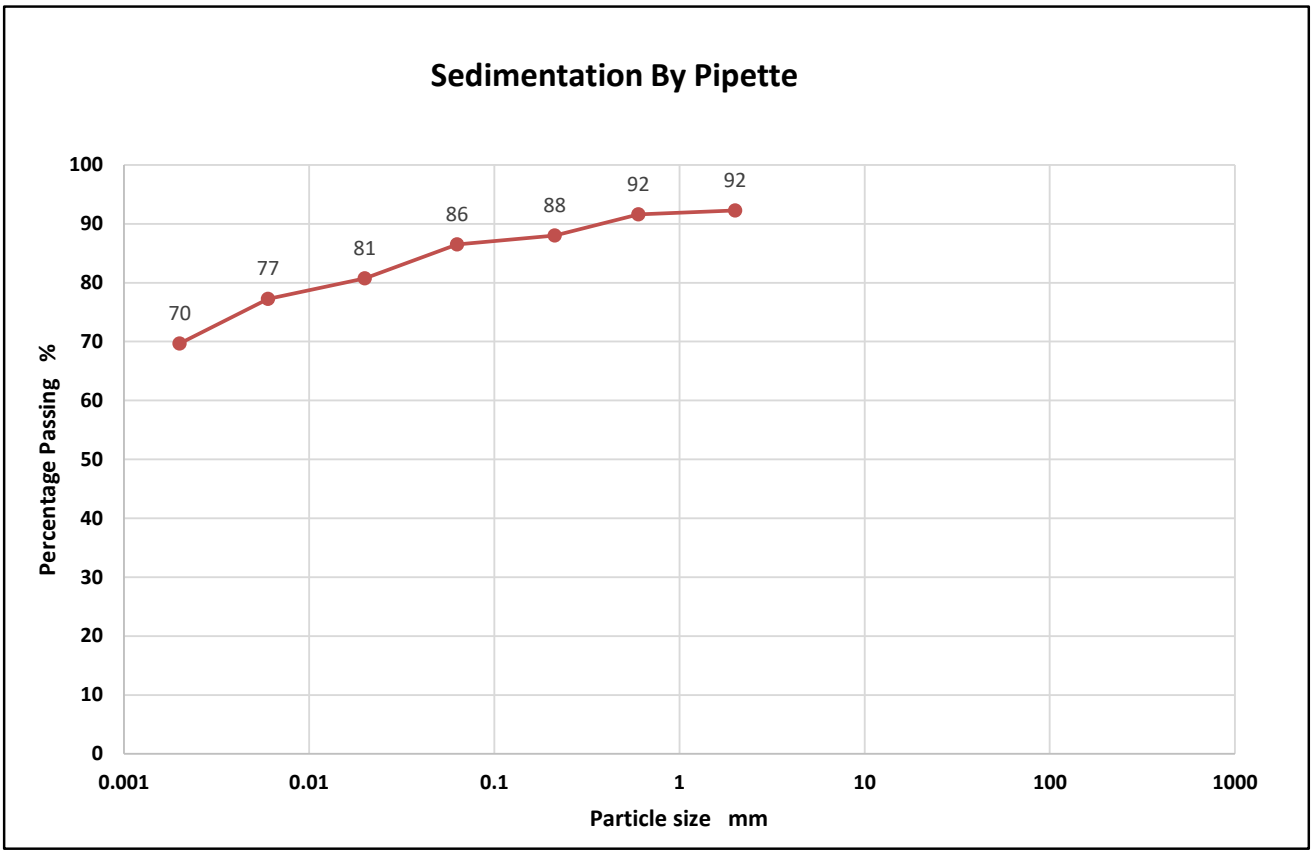
Particle Diameter	Percentage Passing
0.02	79
0.006	76
0.002	72

Soil Fraction	Total Percentage
Gravel	8
Sand	10
Silt	10
Clay	72

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH6
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown sandy fine to medium gravelly silty CLAY	Depth Top	0.50
		Depth Base	
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	92
0.60	92
0.212	88
0.063	86

Sedimentation Analysis

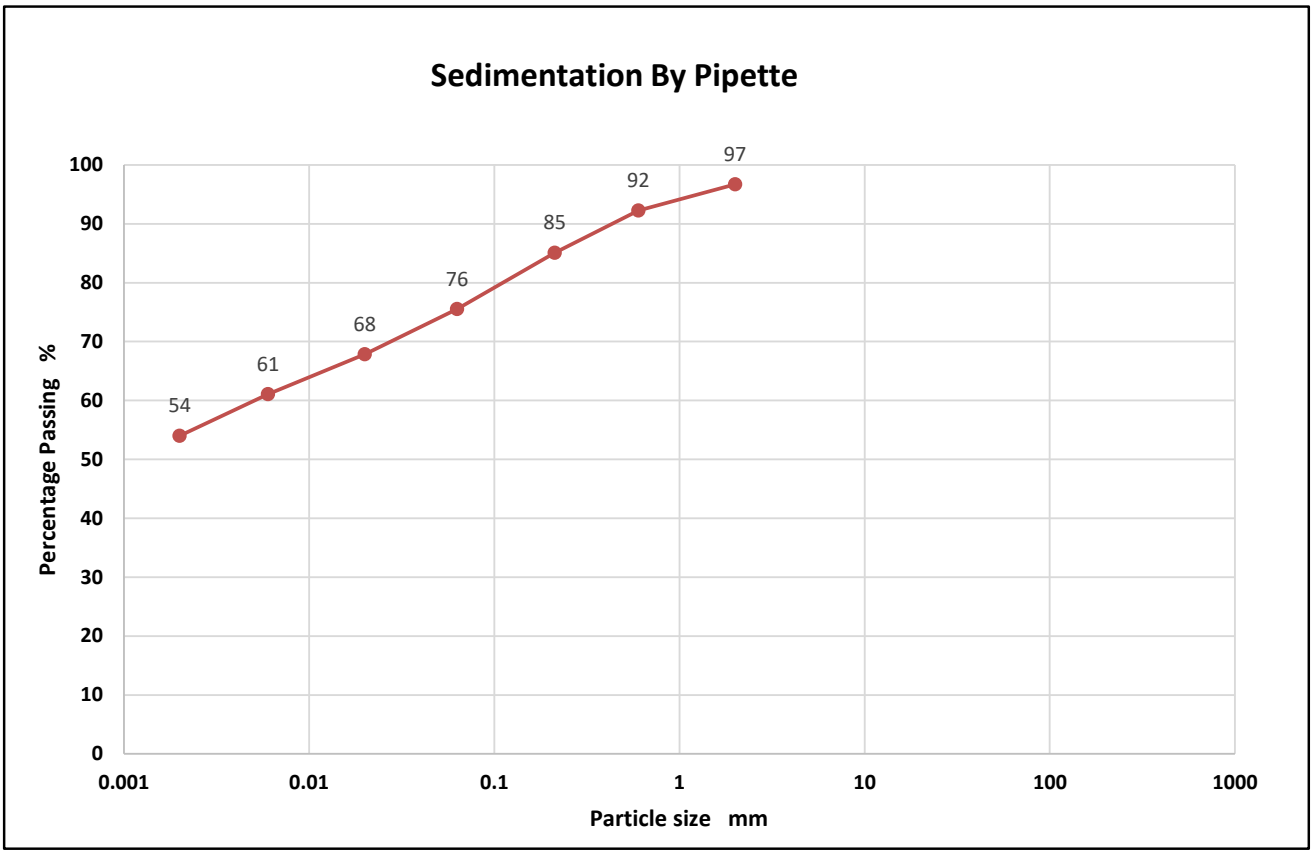
Particle Diameter	Percentage Passing
0.02	81
0.006	77
0.002	70

Soil Fraction	Total Percentage
Gravel	8
Sand	6
Silt	17
Clay	70

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH6
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine to medium gravelly, sandy, silty CLAY	Depth Top	2.00
		Depth Base	
		Sample Type	UT



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	97
0.60	92
0.212	85
0.063	76

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	68
0.006	61
0.002	54

Soil Fraction	Total Percentage
Gravel	3
Sand	21
Silt	22
Clay	54

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

UKAS TESTING
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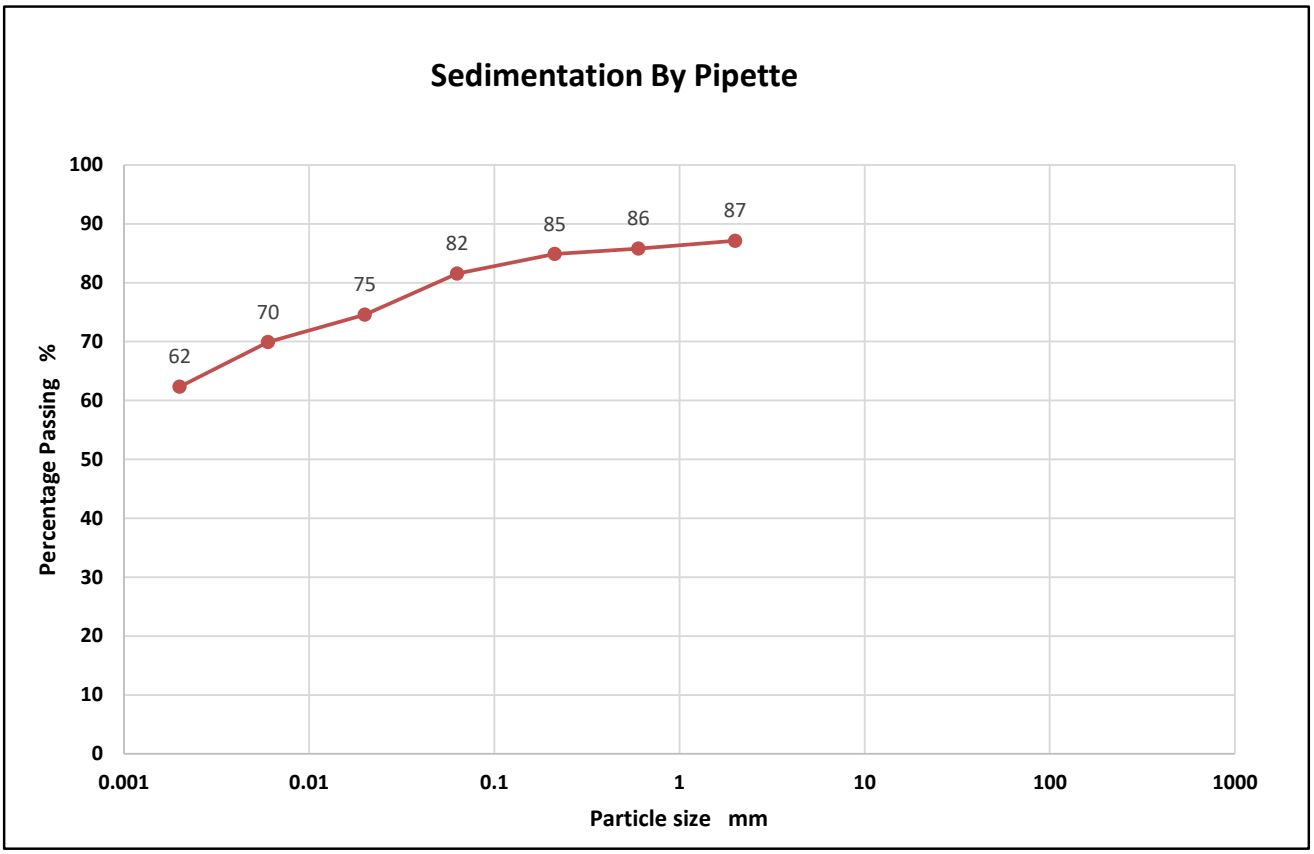
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH6
Site Name	A40 RCE	Sample No.	20
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	5.00
		Depth Base	5.45
		Sample Type	UT



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	87
0.60	86
0.212	85
0.063	82

Sedimentation Analysis

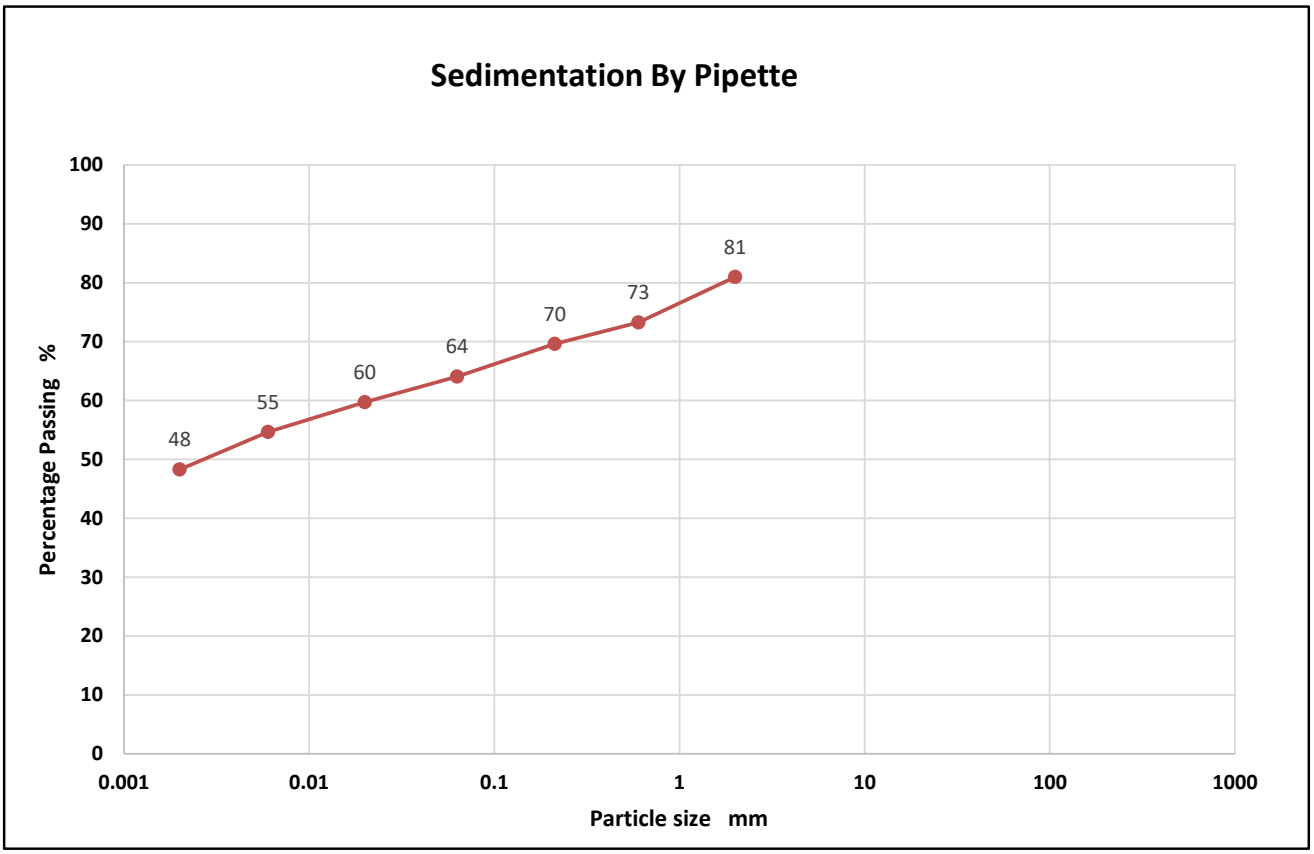
Particle Diameter	Percentage Passing
0.02	75
0.006	70
0.002	62

Soil Fraction	Total Percentage
Gravel	13
Sand	6
Silt	19
Clay	62

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH6
Site Name	A40 RCE	Sample No.	23
Soil Description	Brown sandy sily fine to medium gravelly CLAY	Depth Top	6.30
		Depth Base	6.50
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	81
0.60	73
0.212	70
0.063	64

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	60
0.006	55
0.002	48

Soil Fraction	Total Percentage
Gravel	19
Sand	17
Silt	16
Clay	48

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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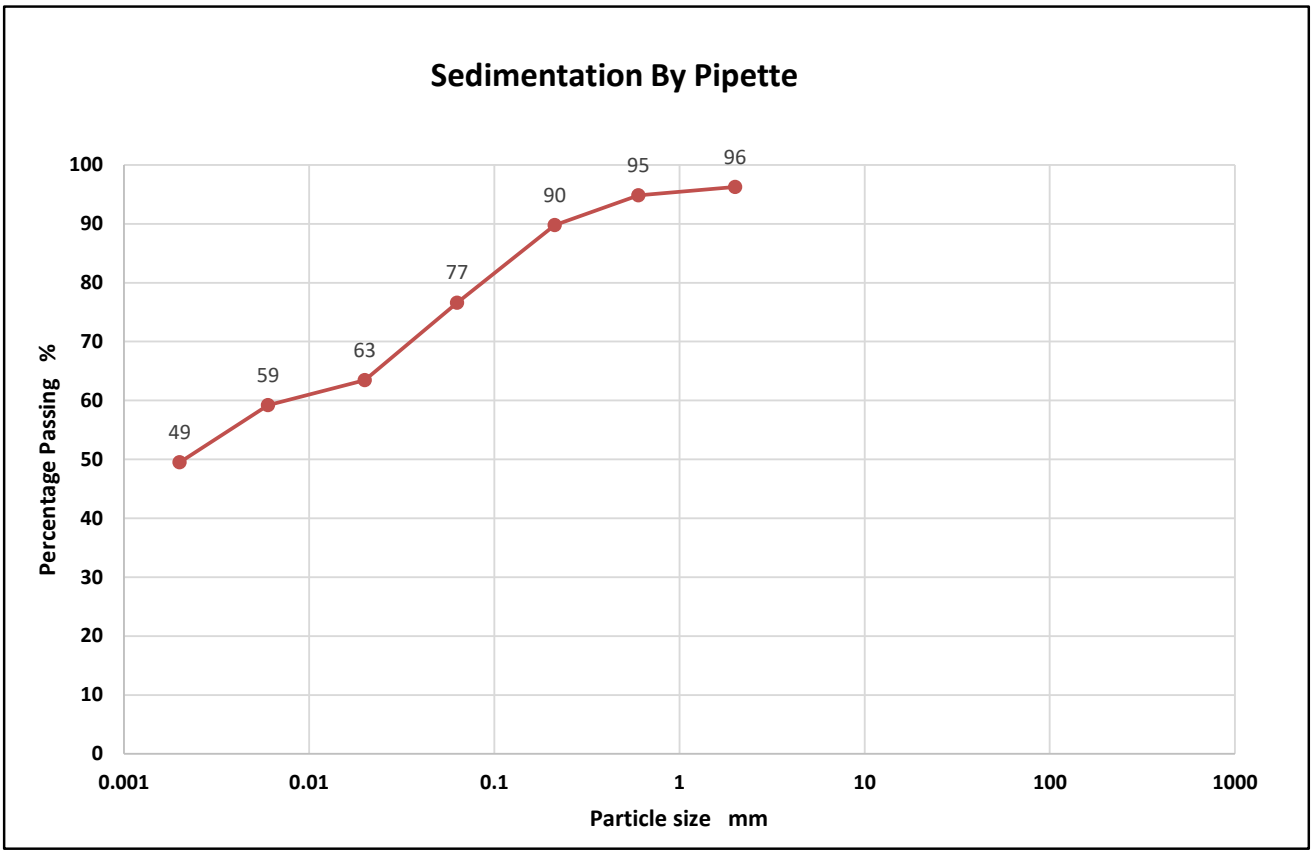
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH7
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine to medium gravelly, sandy, silty CLAY	Depth Top	2.00
		Depth Base	2.45
		Sample Type	UT



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	95
0.212	90
0.063	77

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	63
0.006	59
0.002	49

Soil Fraction	Total Percentage
Gravel	4
Sand	20
Silt	27
Clay	49

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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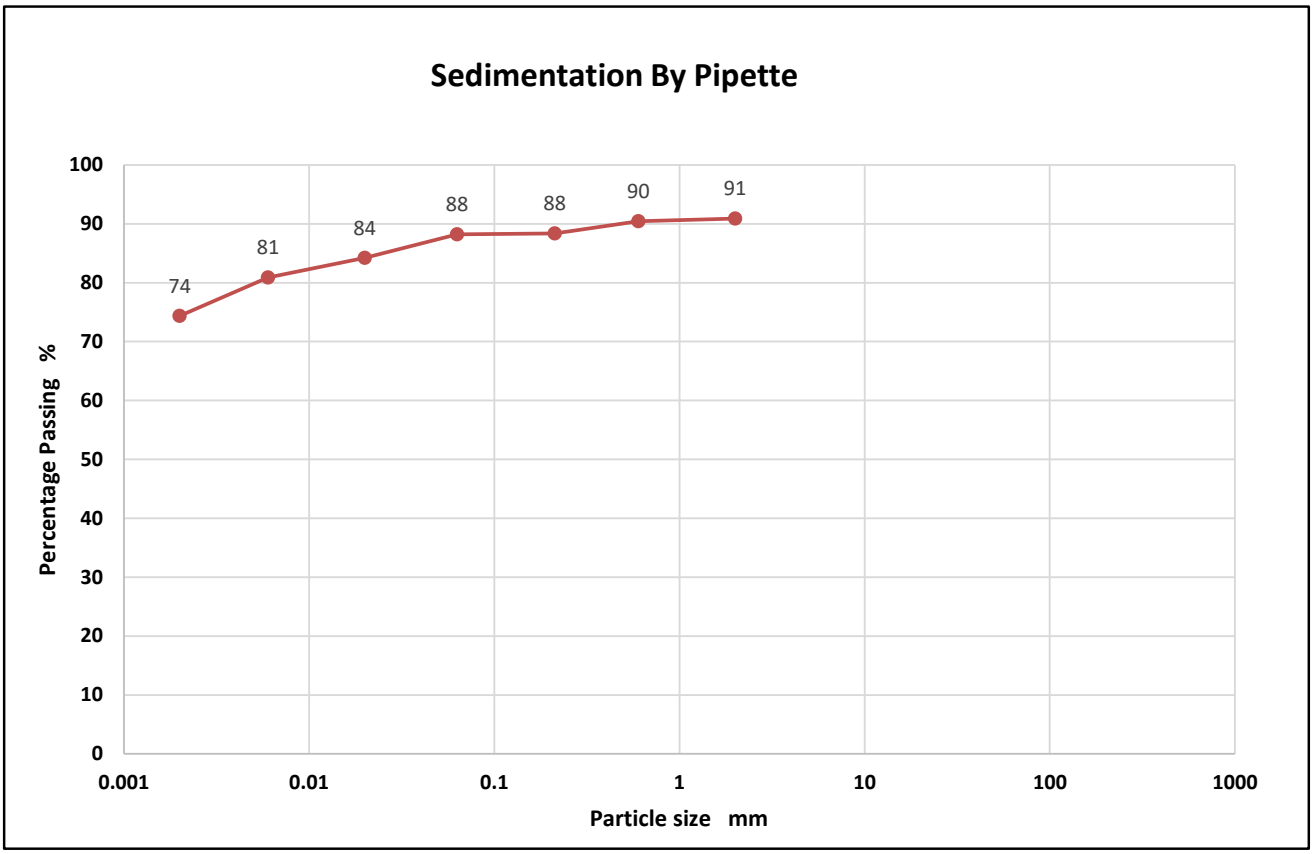
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH7
Site Name	A40 RCE	Sample No.	17
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	4.00
		Depth Base	4.50
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	91
0.60	90
0.212	88
0.063	88

Sedimentation Analysis

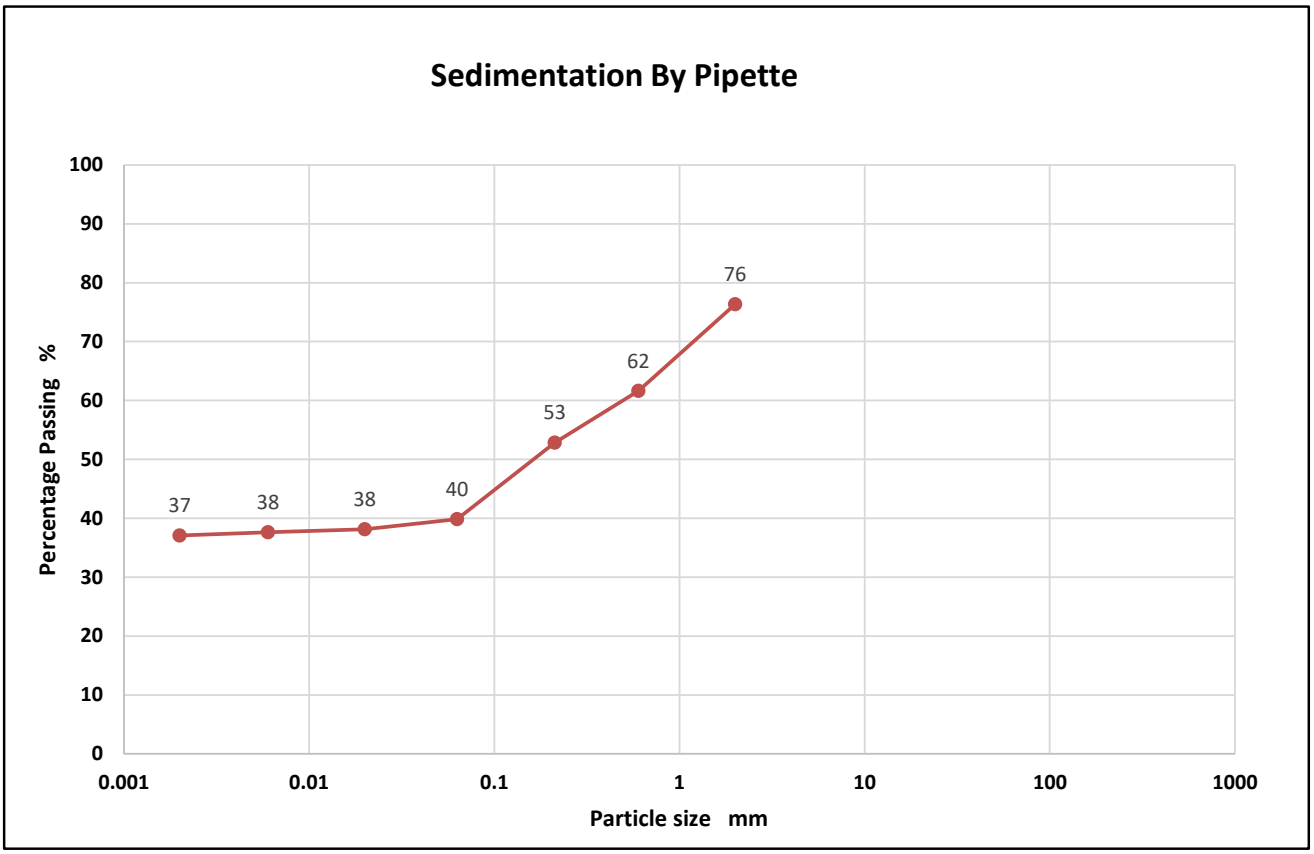
Particle Diameter	Percentage Passing
0.02	84
0.006	81
0.002	74

Soil Fraction	Total Percentage
Gravel	9
Sand	3
Silt	14
Clay	74

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH7
Site Name	A40 RCE	Sample No.	21
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	6.50
		Depth Base	7.00
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	76
0.60	62
0.212	53
0.063	40

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	38
0.006	38
0.002	37

Soil Fraction	Total Percentage
Gravel	24
Sand	36
Silt	3
Clay	37

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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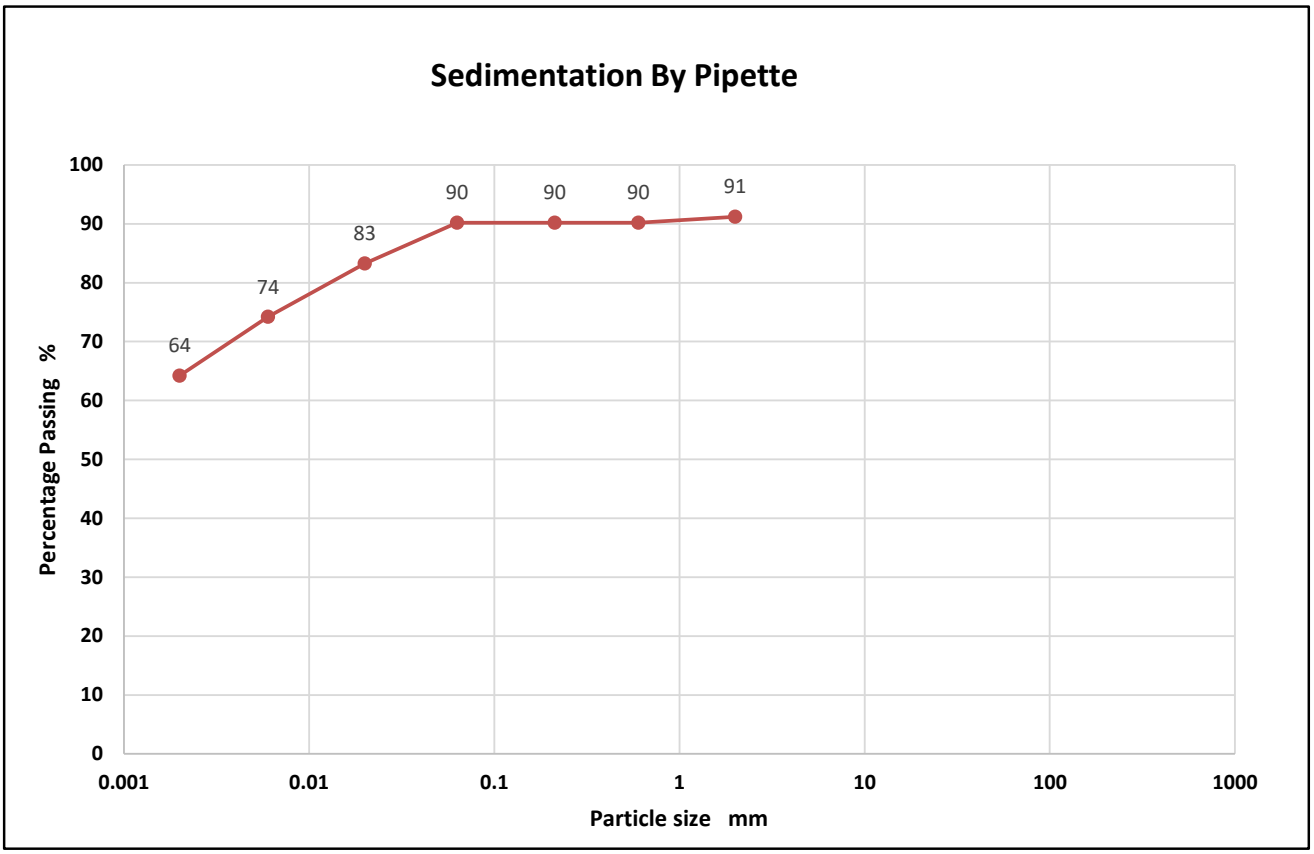
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH8
Site Name	A40 RCE	Sample No.	7
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	2.20
		Depth Base	2.65
		Sample Type	UT



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	91
0.60	90
0.212	90
0.063	90

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	83
0.006	74
0.002	64

Soil Fraction	Total Percentage
Gravel	9
Sand	1
Silt	26
Clay	64

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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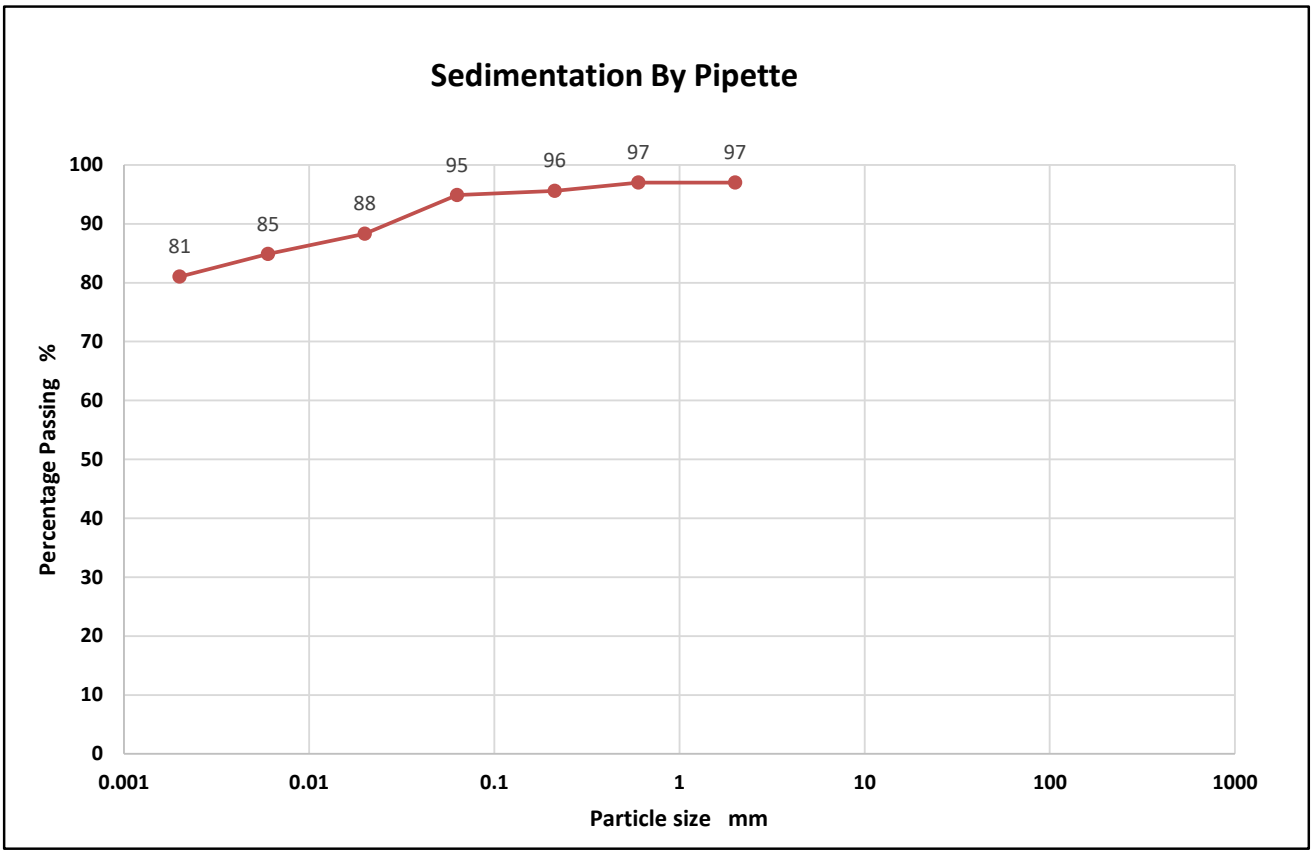
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH8
Site Name	A40 RCE	Sample No.	11
Soil Description	Brown slightly sandy, slightly gravelly, silty CLAY	Depth Top	3.20
		Depth Base	3.65
		Sample Type	UT



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	97
0.60	97
0.212	96
0.063	95

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	88
0.006	85
0.002	81

Soil Fraction	Total Percentage
Gravel	3
Sand	2
Silt	14
Clay	81

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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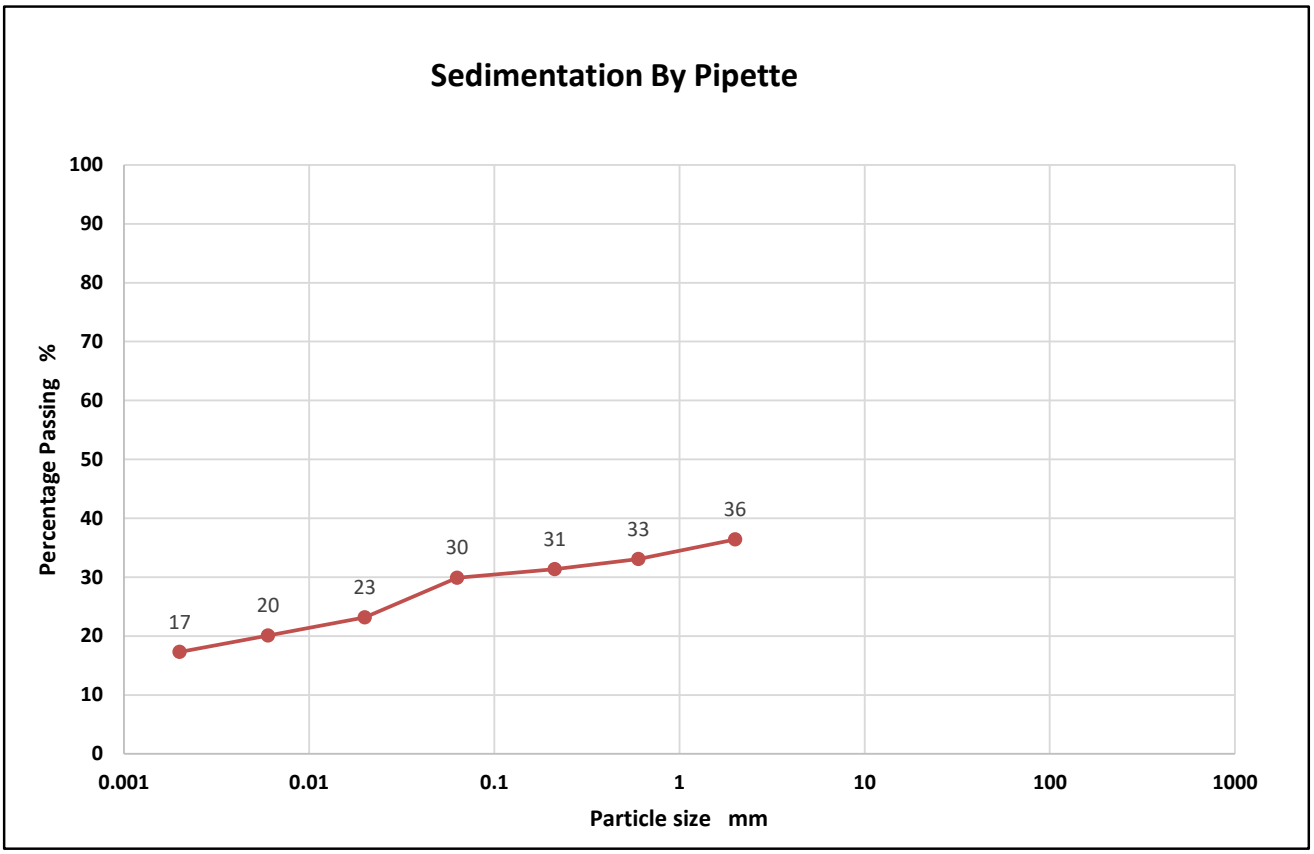
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH9
Site Name	A40 RCE	Sample No.	8
Soil Description	Black slightly sandy, silty, clayey, fine to medium GRAVEL	Depth Top	2.1m
		Depth Base	2.5m
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	36
0.60	33
0.212	31
0.063	30

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	23
0.006	20
0.002	17

Soil Fraction	Total Percentage
Gravel	64
Sand	6
Silt	13
Clay	17

Operators	Checked	26/11/2019	Wayne Honey	W. Honey
RO	Approved	27/11/2019	Paul Evans	D P Evans

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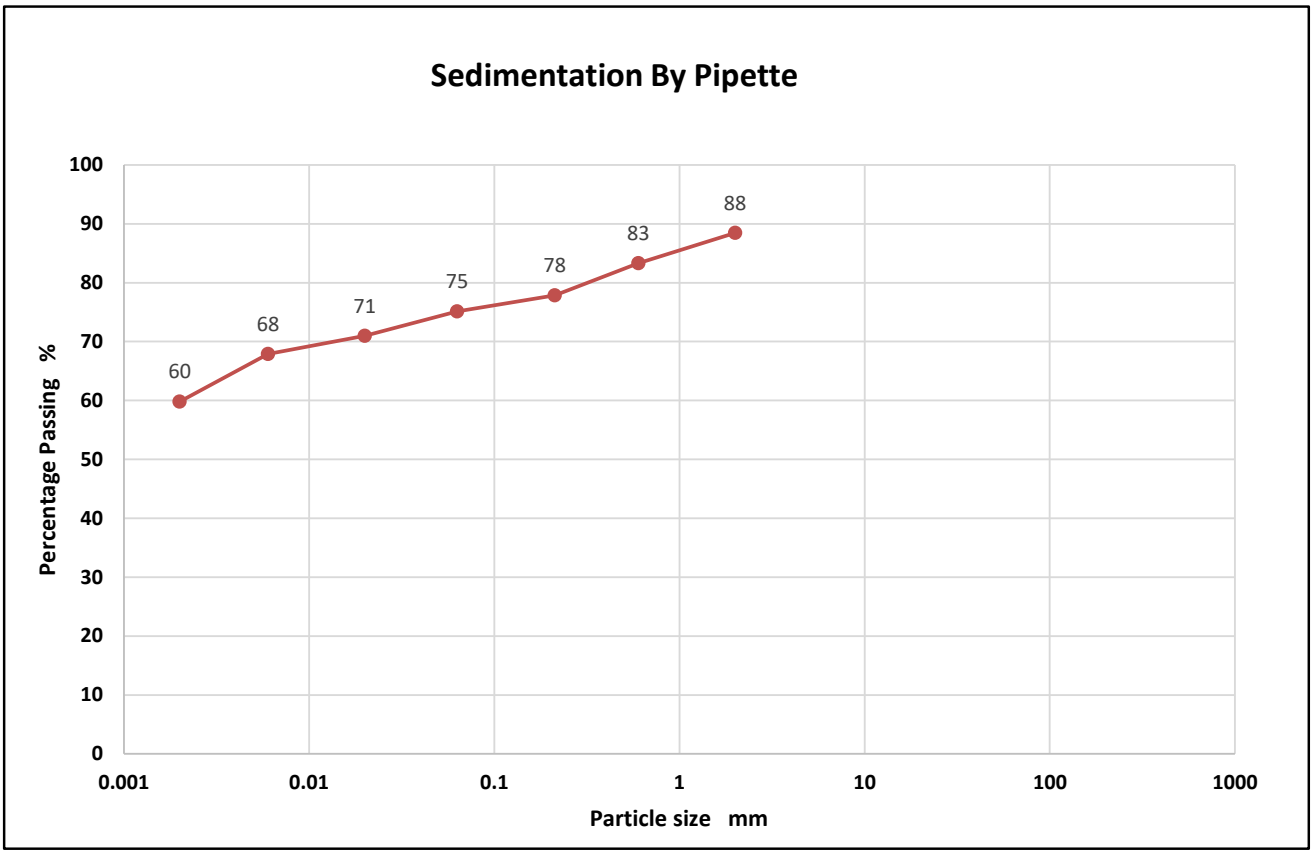
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCEBH12
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown sandy fine to medium gravelly silty CLAY	Depth Top	1.20
		Depth Base	1.50
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	88
0.60	83
0.212	78
0.063	75

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	71
0.006	68
0.002	60

Soil Fraction	Total Percentage
Gravel	12
Sand	13
Silt	15
Clay	60

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

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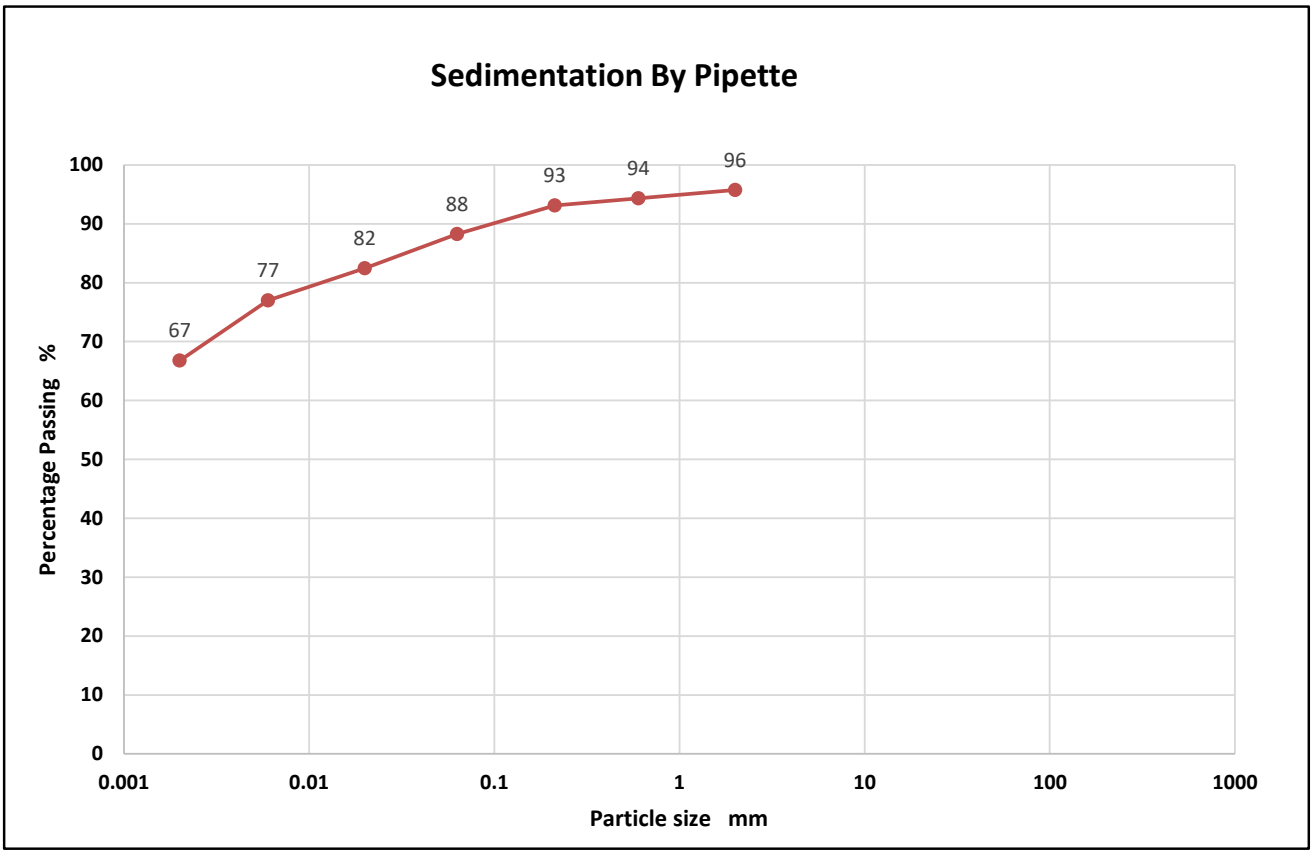
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCESA12
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown fine to medium gravelly, sandy, silty CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	94
0.212	93
0.063	88

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	82
0.006	77
0.002	67

Soil Fraction	Total Percentage
Gravel	4
Sand	7
Silt	22
Clay	67

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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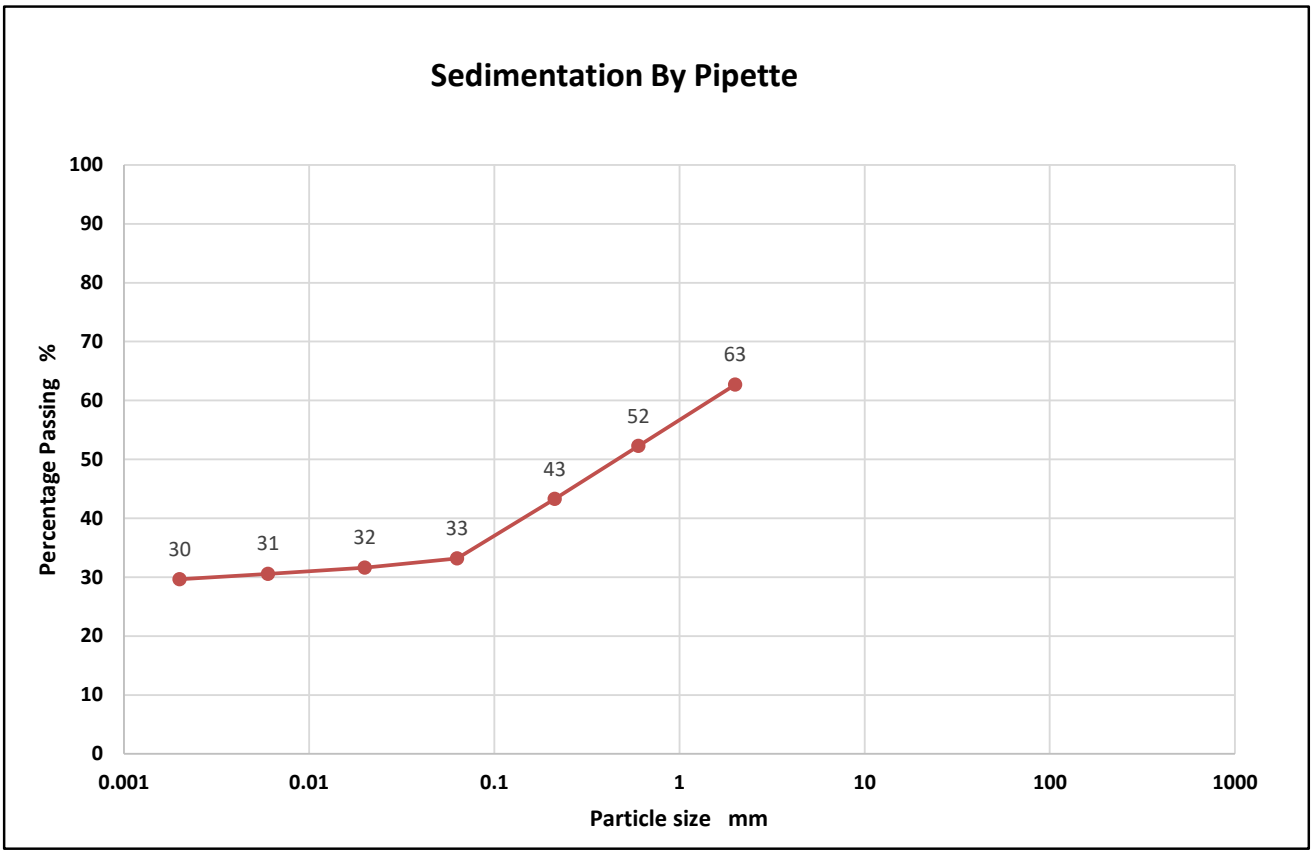
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP3
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy, clayey, fine to medium SHALE	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	63
0.60	52
0.212	43
0.063	33

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	32
0.006	31
0.002	30

Soil Fraction	Total Percentage
Gravel	37
Sand	30
Silt	4
Clay	30

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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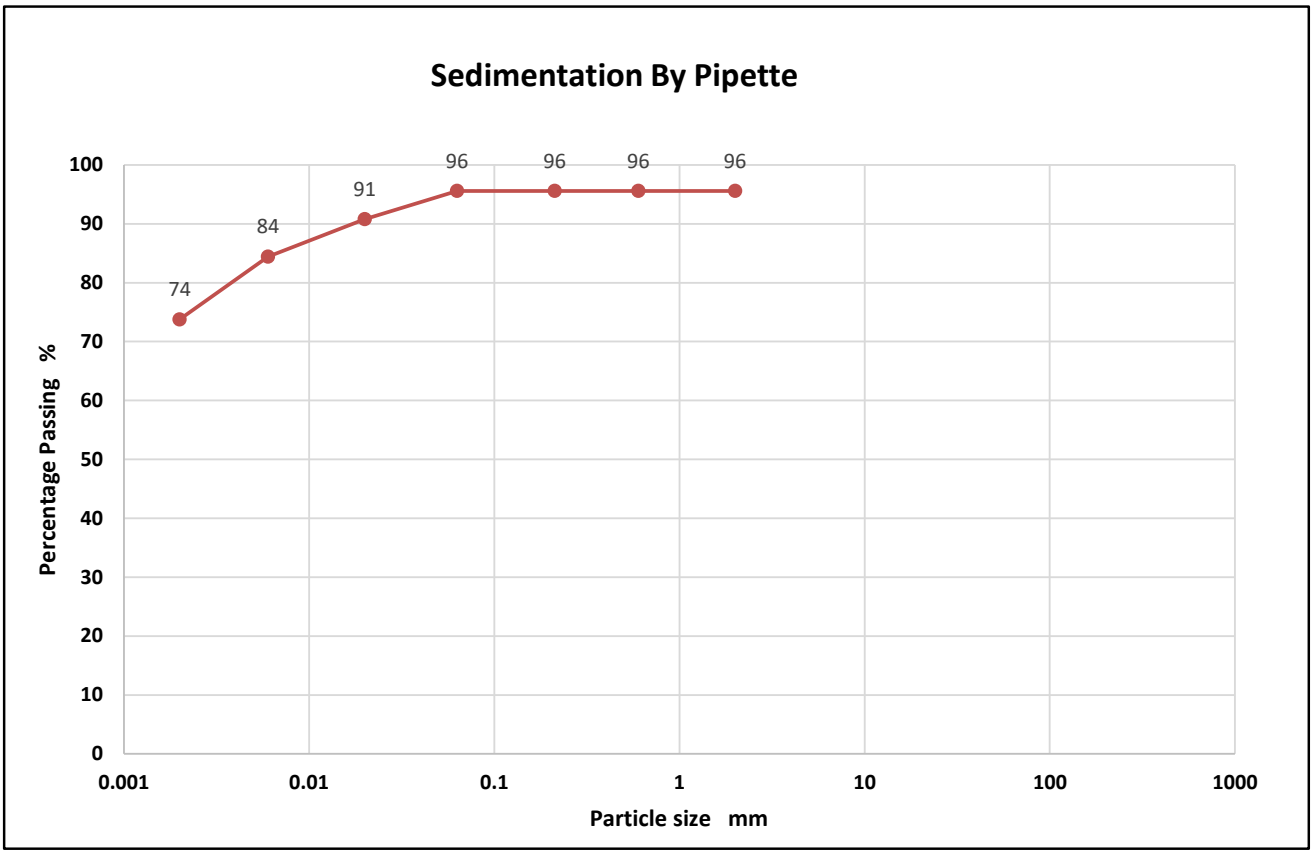
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP3
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	2.50
		Depth Base	3.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	96
0.212	96
0.063	96

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	91
0.006	84
0.002	74

Soil Fraction	Total Percentage
Gravel	4
Sand	0
Silt	22
Clay	74

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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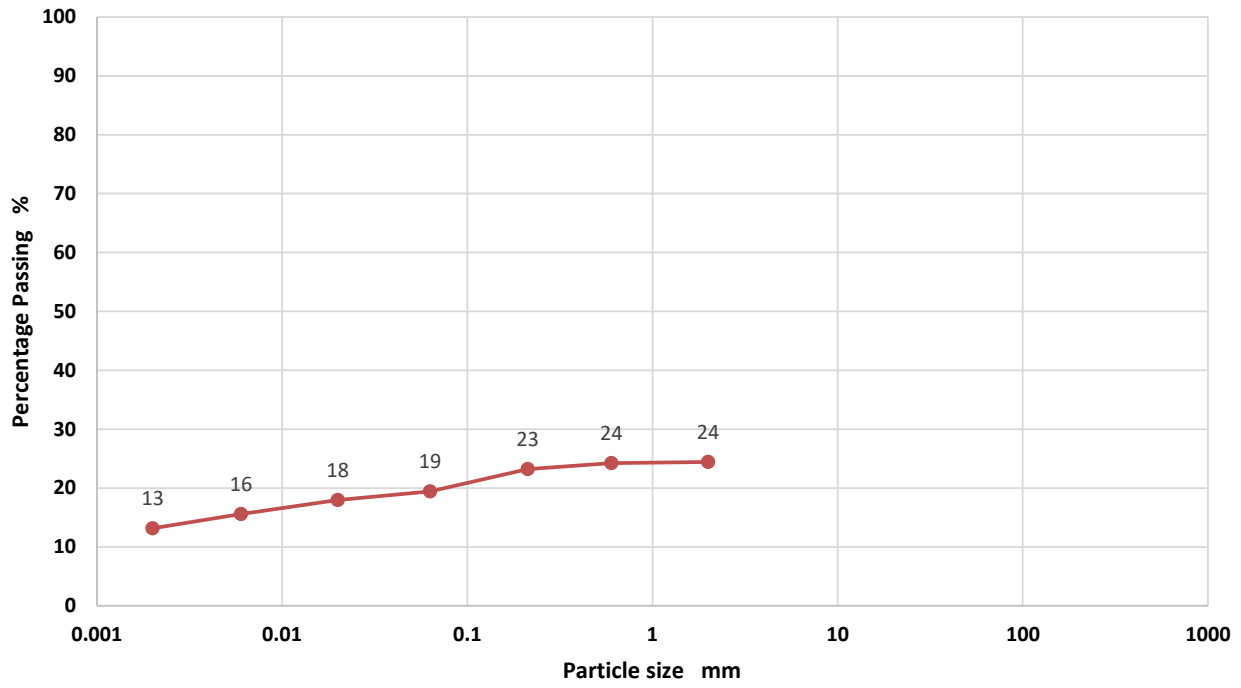
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP4
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown slightly sandy, slightly silty, clayey fine to coarse GRAVEL	Depth Top	1.00
		Depth Base	1.50
		Sample Type	LB

Sedimentation By Pipette



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	24
0.60	24
0.212	23
0.063	19

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	18
0.006	16
0.002	13

Soil Fraction	Total Percentage
Gravel	76
Sand	5
Silt	6
Clay	13

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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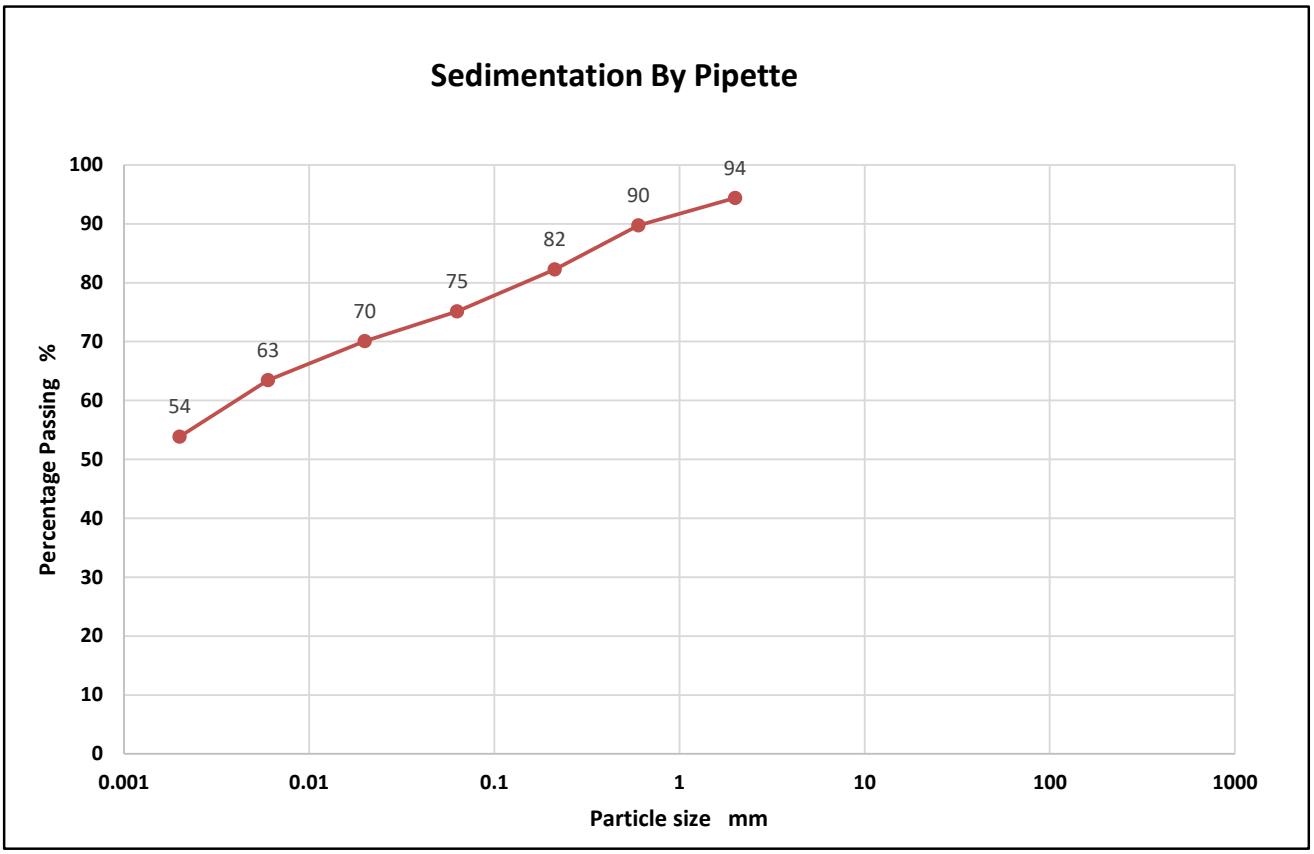
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP5
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown fine to medium gravelly, sandy, silty CLAY	Depth Top	0.50
		Depth Base	0.60
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	94
0.60	90
0.212	82
0.063	75

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	70
0.006	63
0.002	54

Soil Fraction	Total Percentage
Gravel	6
Sand	19
Silt	21
Clay	54

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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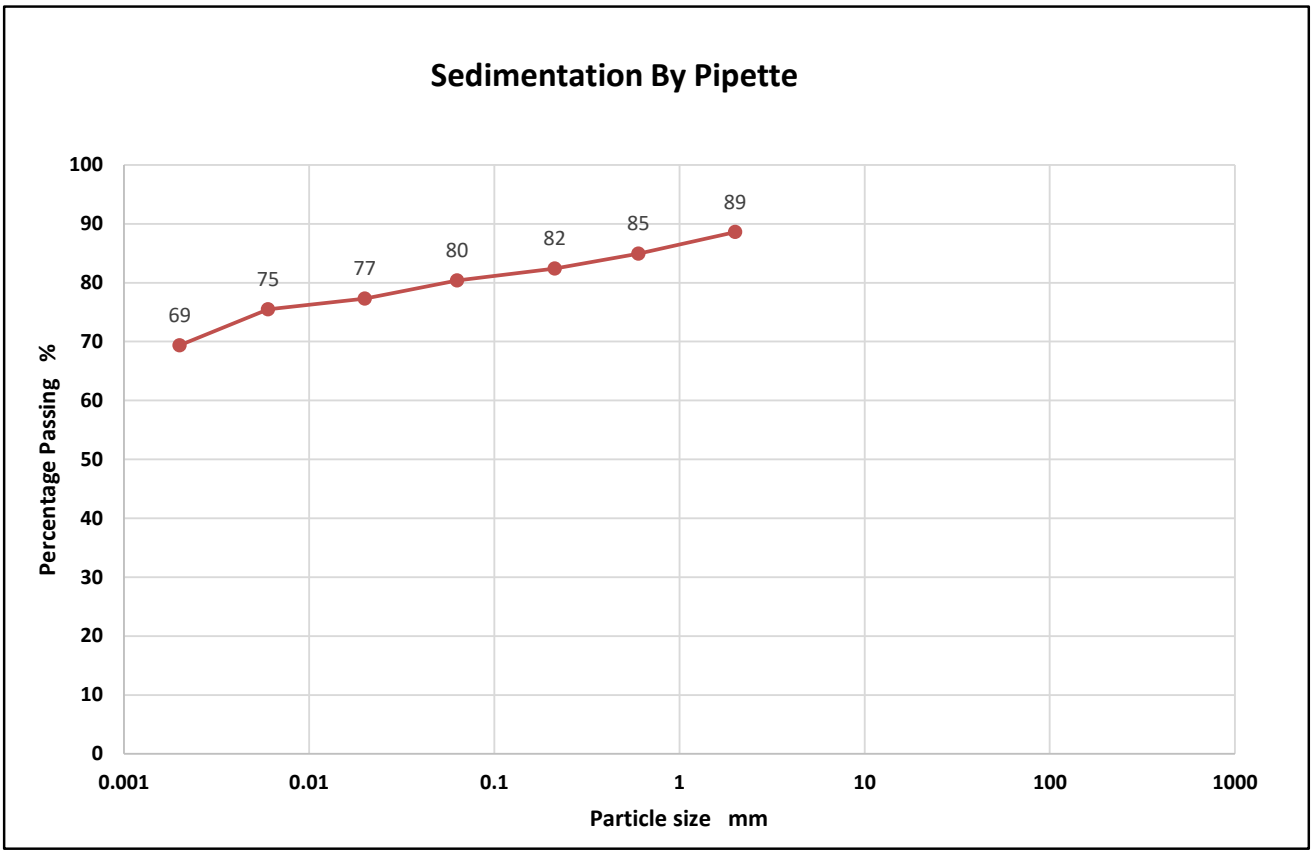
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP8
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy silty fine to medium gravelly CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	89
0.60	85
0.212	82
0.063	80

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	77
0.006	75
0.002	69

Soil Fraction	Total Percentage
Gravel	11
Sand	8
Silt	11
Clay	69

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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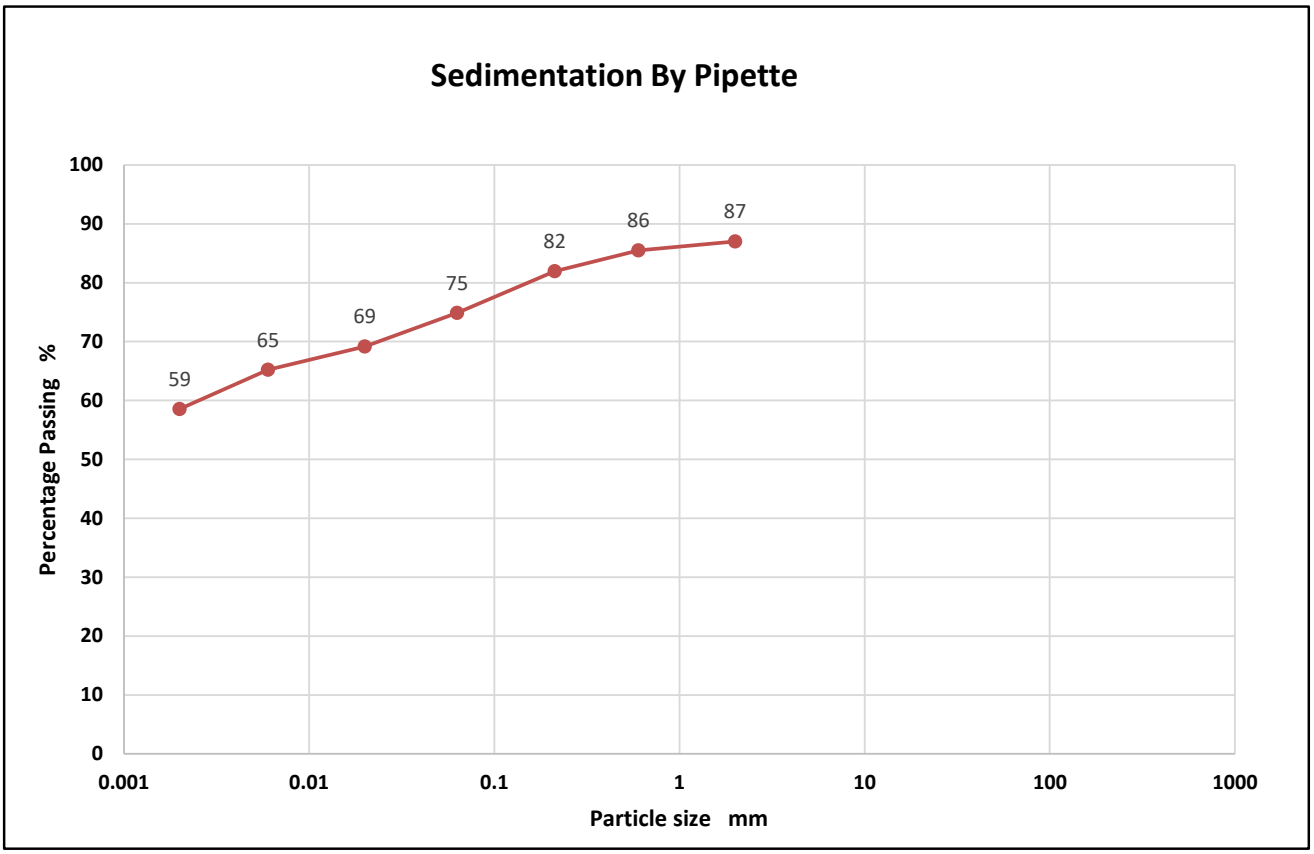
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP8
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	2.50
		Depth Base	2.90
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	87
0.60	86
0.212	82
0.063	75

Sedimentation Analysis

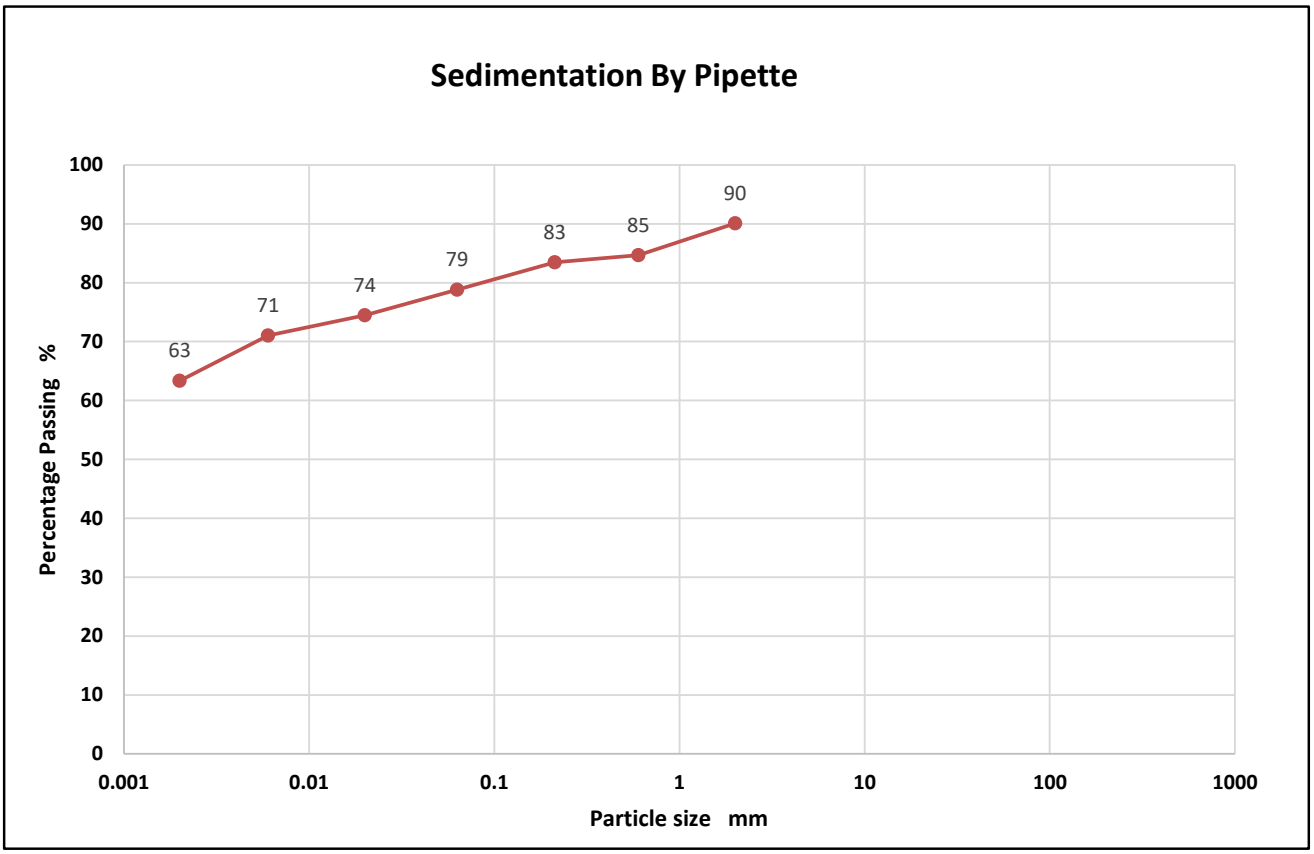
Particle Diameter	Percentage Passing
0.02	69
0.006	65
0.002	59

Soil Fraction	Total Percentage
Gravel	13
Sand	12
Silt	16
Clay	59

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP8
Site Name	A40 RCE	Sample No.	7
Soil Description	Brown sandy fine to medium gravelly silty CLAY	Depth Top	3.50
		Depth Base	4.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	90
0.60	85
0.212	83
0.063	79

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	74
0.006	71
0.002	63

Soil Fraction	Total Percentage
Gravel	10
Sand	11
Silt	15
Clay	63

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

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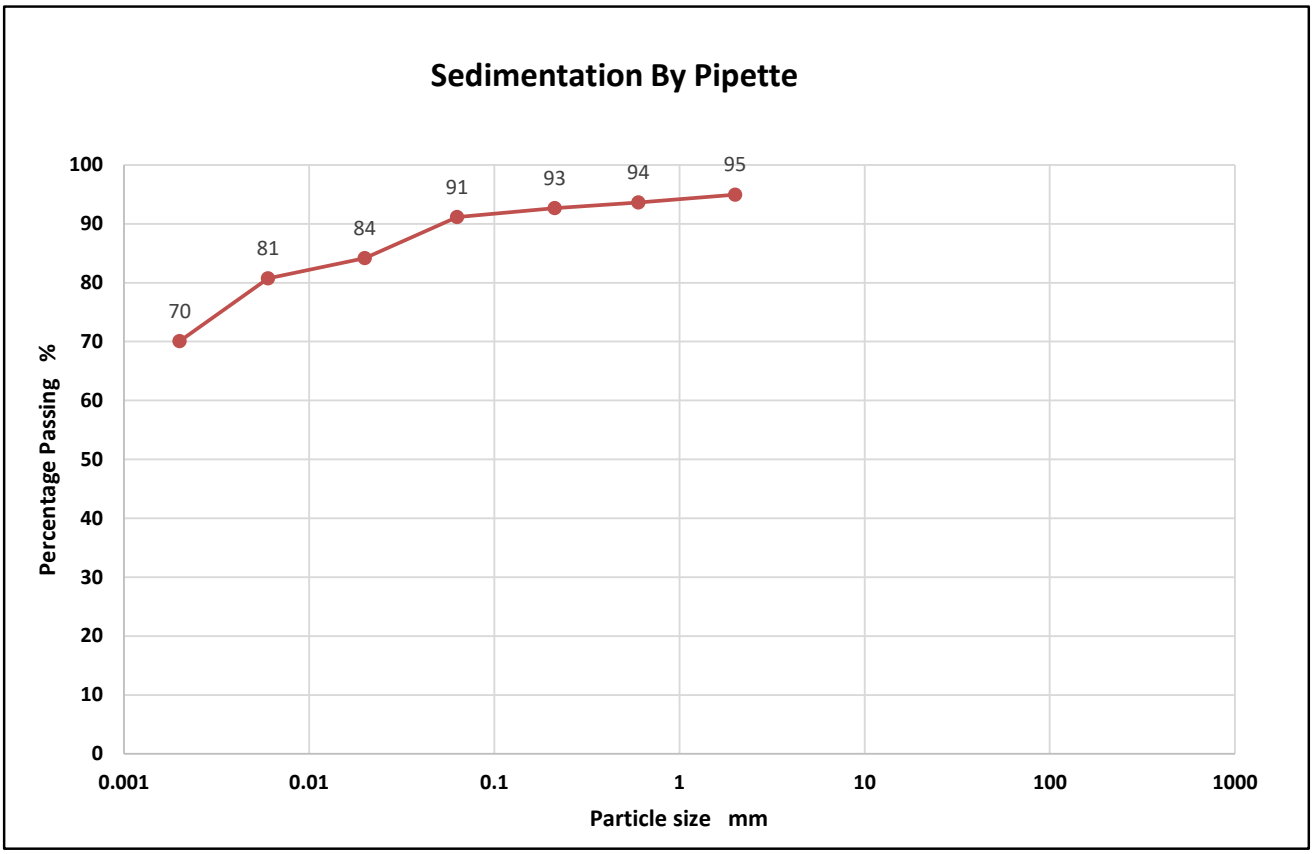
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP9
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	95
0.60	94
0.212	93
0.063	91

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	84
0.006	81
0.002	70

Soil Fraction	Total Percentage
Gravel	5
Sand	4
Silt	21
Clay	70

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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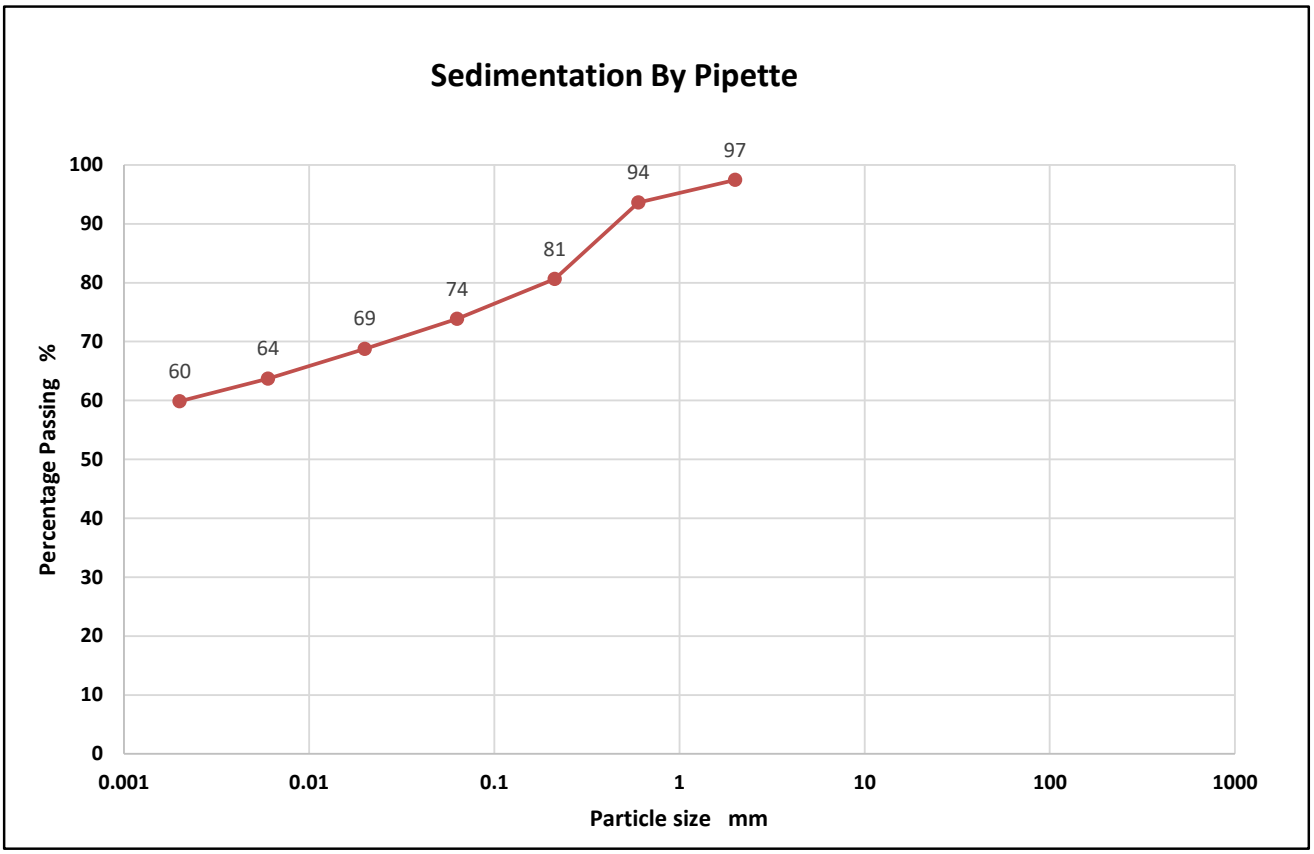
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP9
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to medium gravelly, silty, sandy CLAY	Depth Top	1.50
		Depth Base	2.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	97
0.60	94
0.212	81
0.063	74

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	69
0.006	64
0.002	60

Soil Fraction	Total Percentage
Gravel	3
Sand	24
Silt	14
Clay	60

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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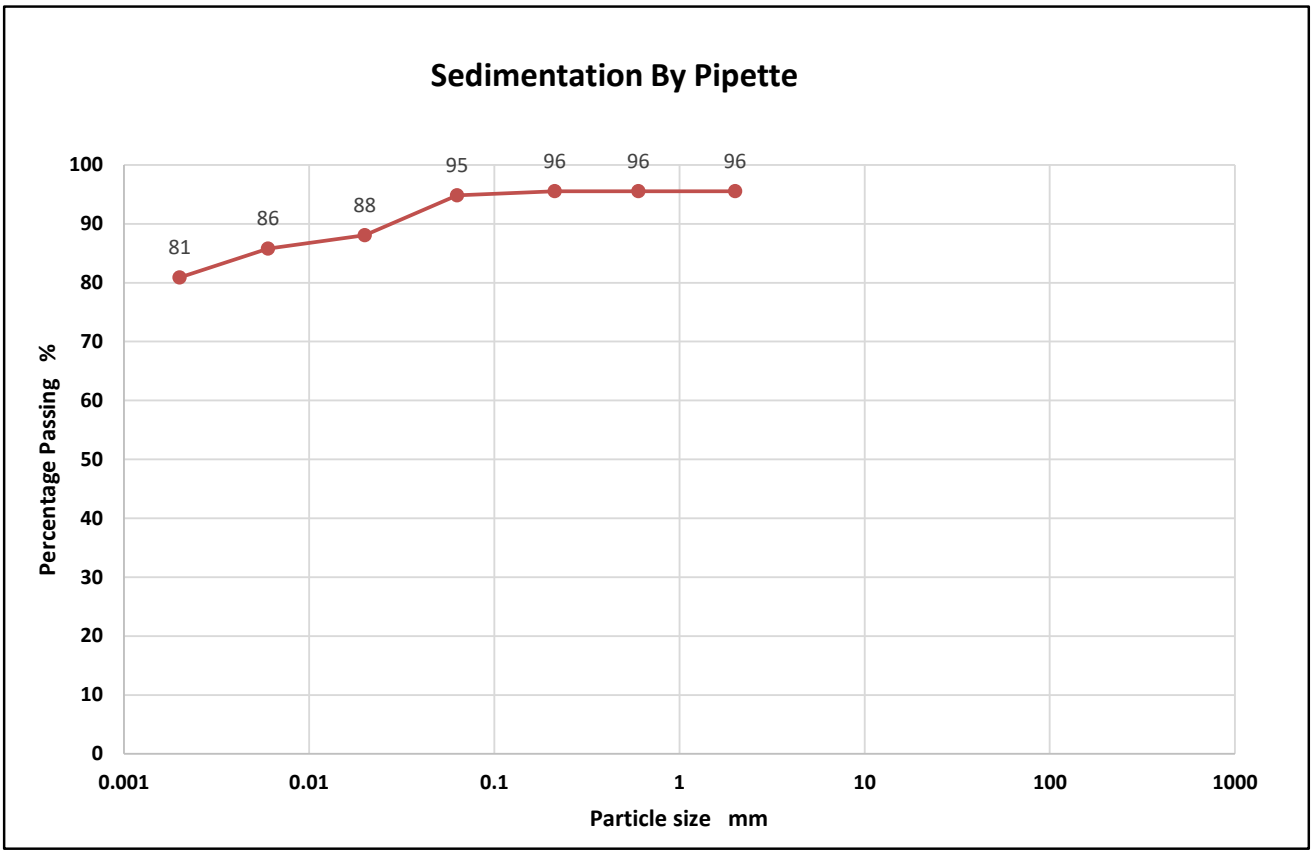
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP9
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	2.50
		Depth Base	3.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	96
0.212	96
0.063	95

Sedimentation Analysis

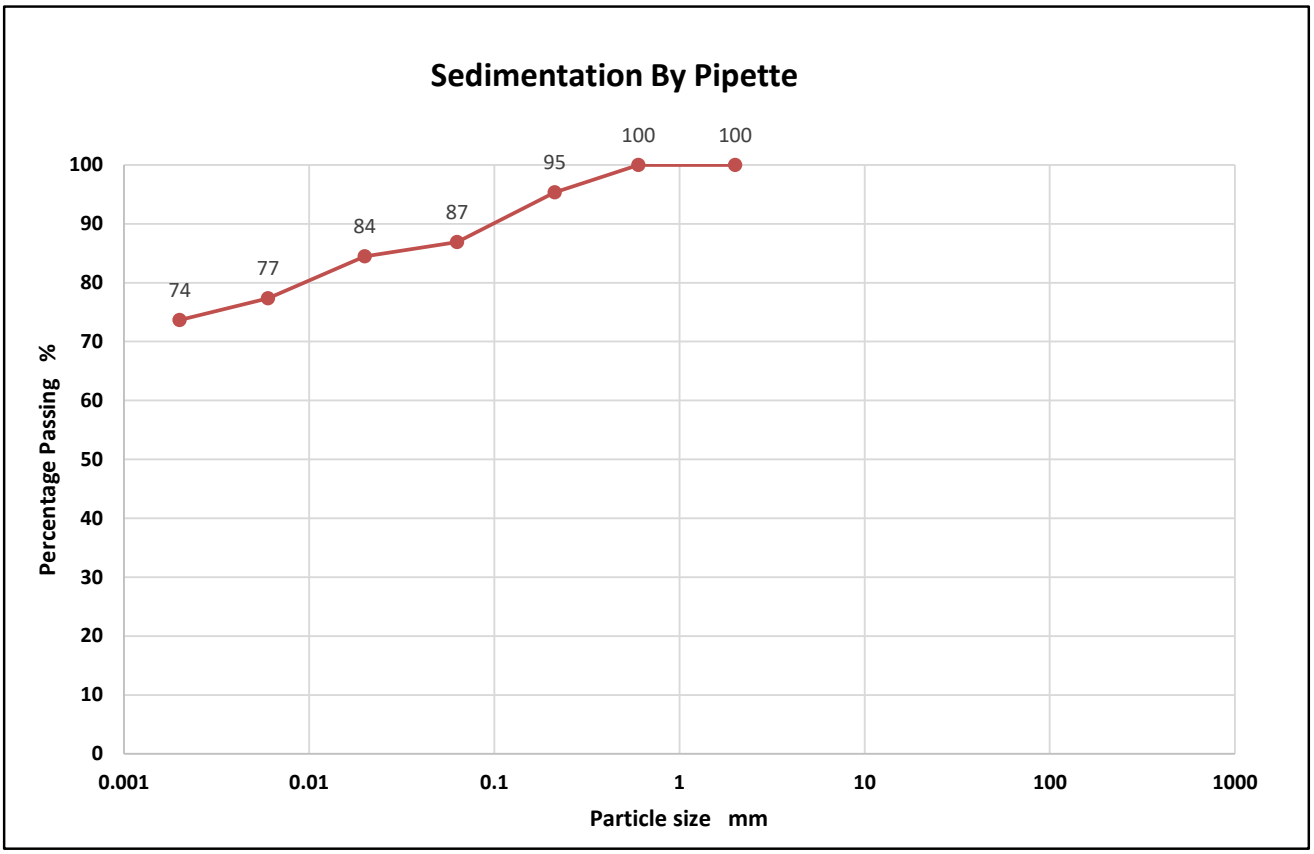
Particle Diameter	Percentage Passing
0.02	88
0.006	86
0.002	81

Soil Fraction	Total Percentage
Gravel	4
Sand	1
Silt	14
Clay	81

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP10
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy silty CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	100
0.60	100
0.212	95
0.063	87

Sedimentation Analysis

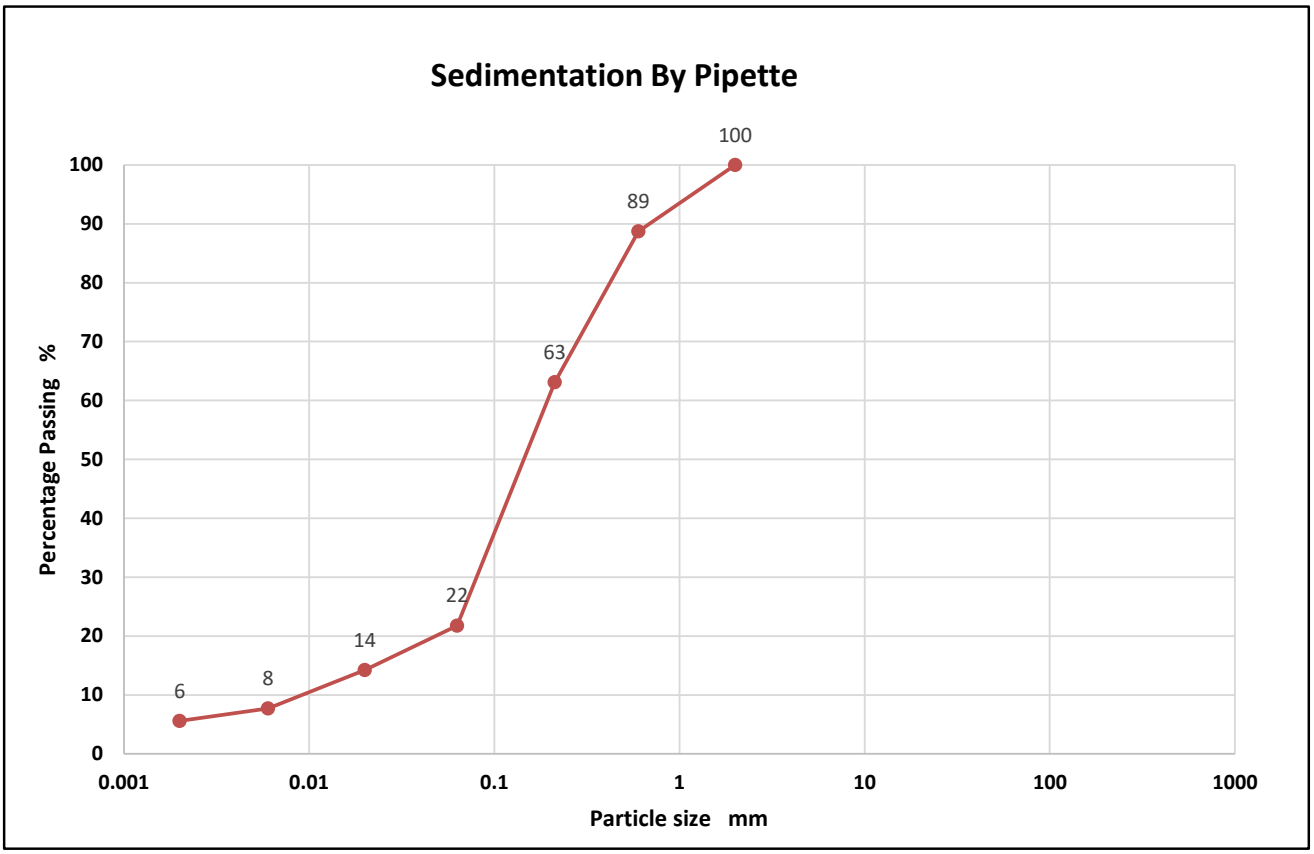
Particle Diameter	Percentage Passing
0.02	84
0.006	77
0.002	74

Soil Fraction	Total Percentage
Gravel	0
Sand	13
Silt	13
Clay	74

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP10
Site Name	A40 RCE	Sample No.	6
Soil Description	Brown clayey silty SAND	Depth Top	1.50
		Depth Base	2.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	100
0.60	89
0.212	63
0.063	22

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	14
0.006	8
0.002	6

Soil Fraction	Total Percentage
Gravel	0
Sand	78
Silt	16
Clay	6

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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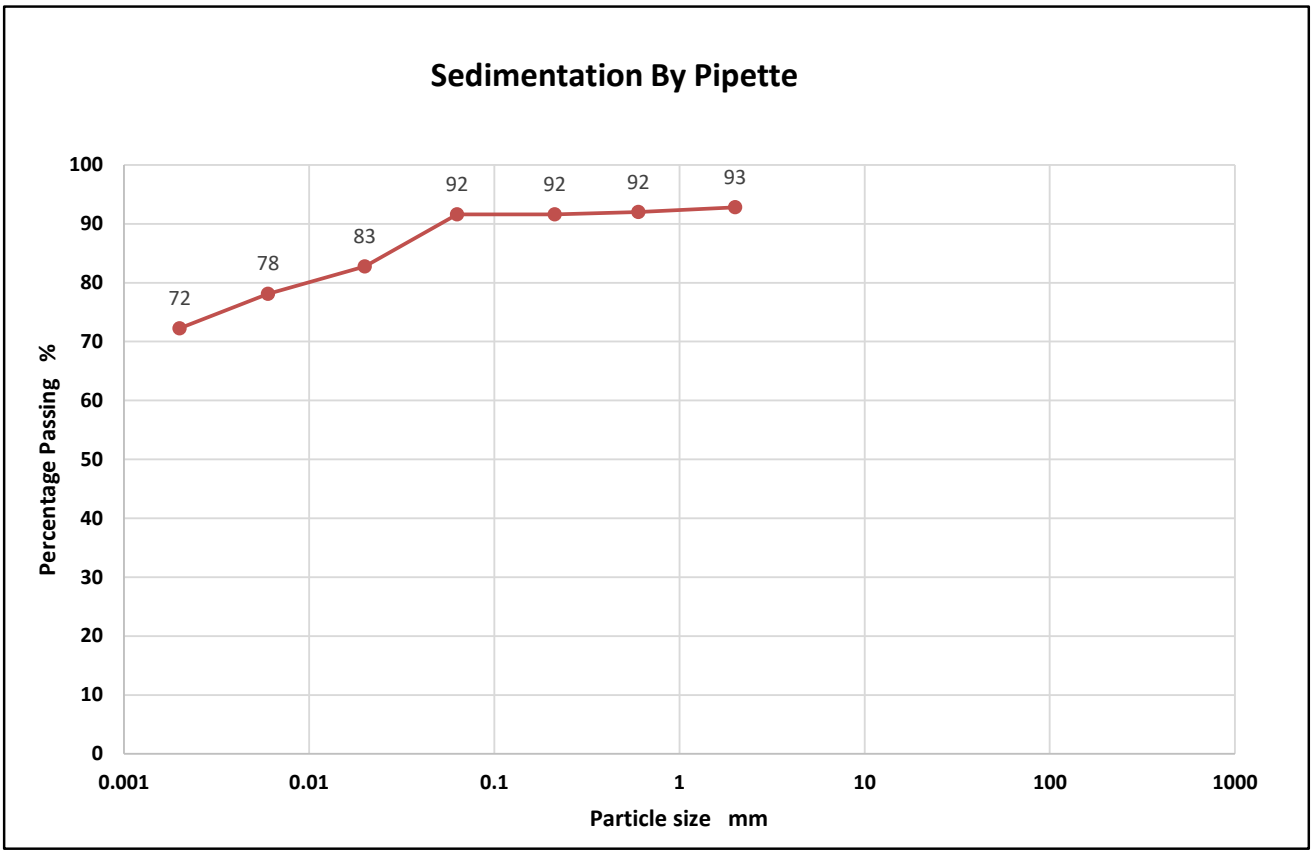
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP10
Site Name	A40 RCE	Sample No.	5
Soil Description	Brown fine to medium, silty CLAY	Depth Top	2.50
		Depth Base	3.00
		Sample Type	B



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	93
0.60	92
0.212	92
0.063	92

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	83
0.006	78
0.002	72

Soil Fraction	Total Percentage
Gravel	7
Sand	1
Silt	19
Clay	72

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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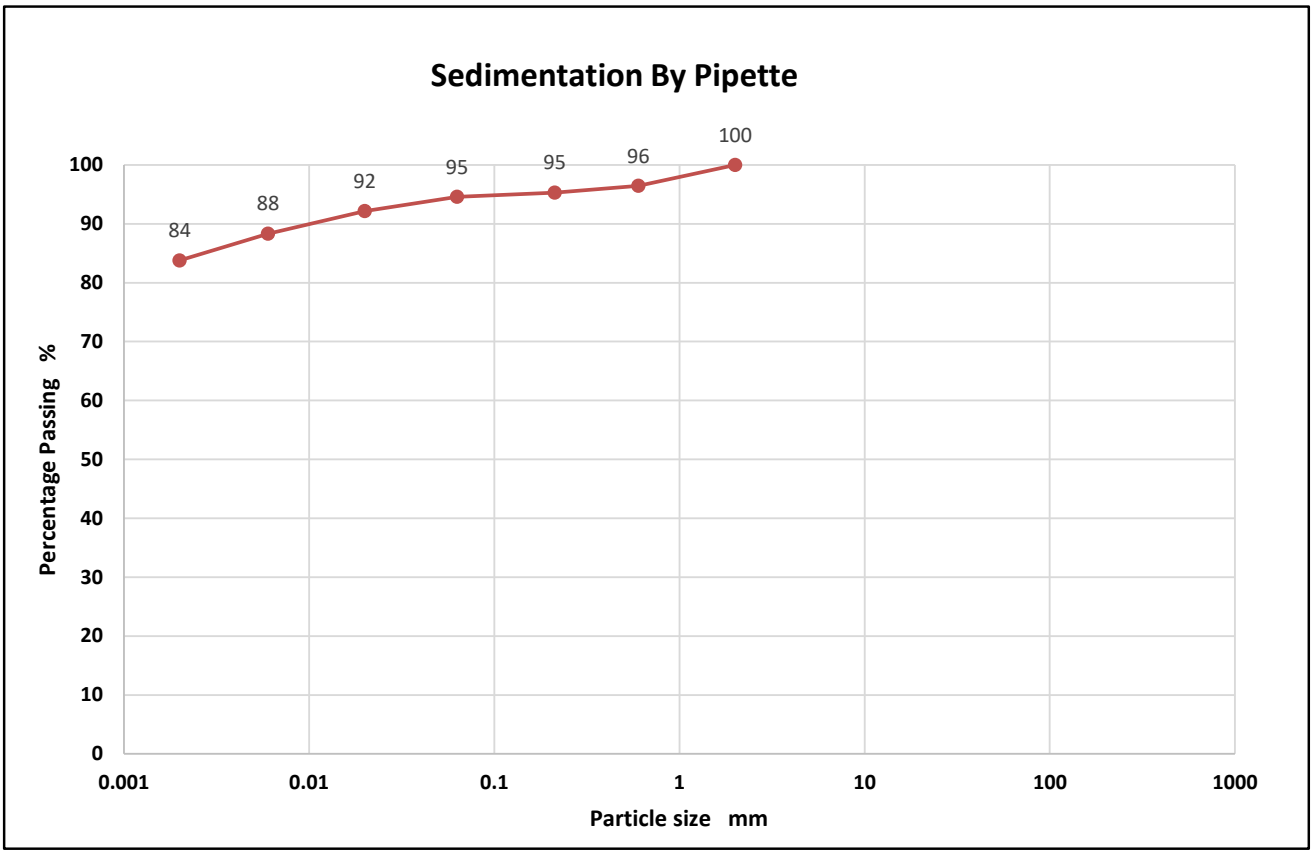
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP11
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy silty CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	100
0.60	96
0.212	95
0.063	95

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	92
0.006	88
0.002	84

Soil Fraction	Total Percentage
Gravel	0
Sand	5
Silt	11
Clay	84

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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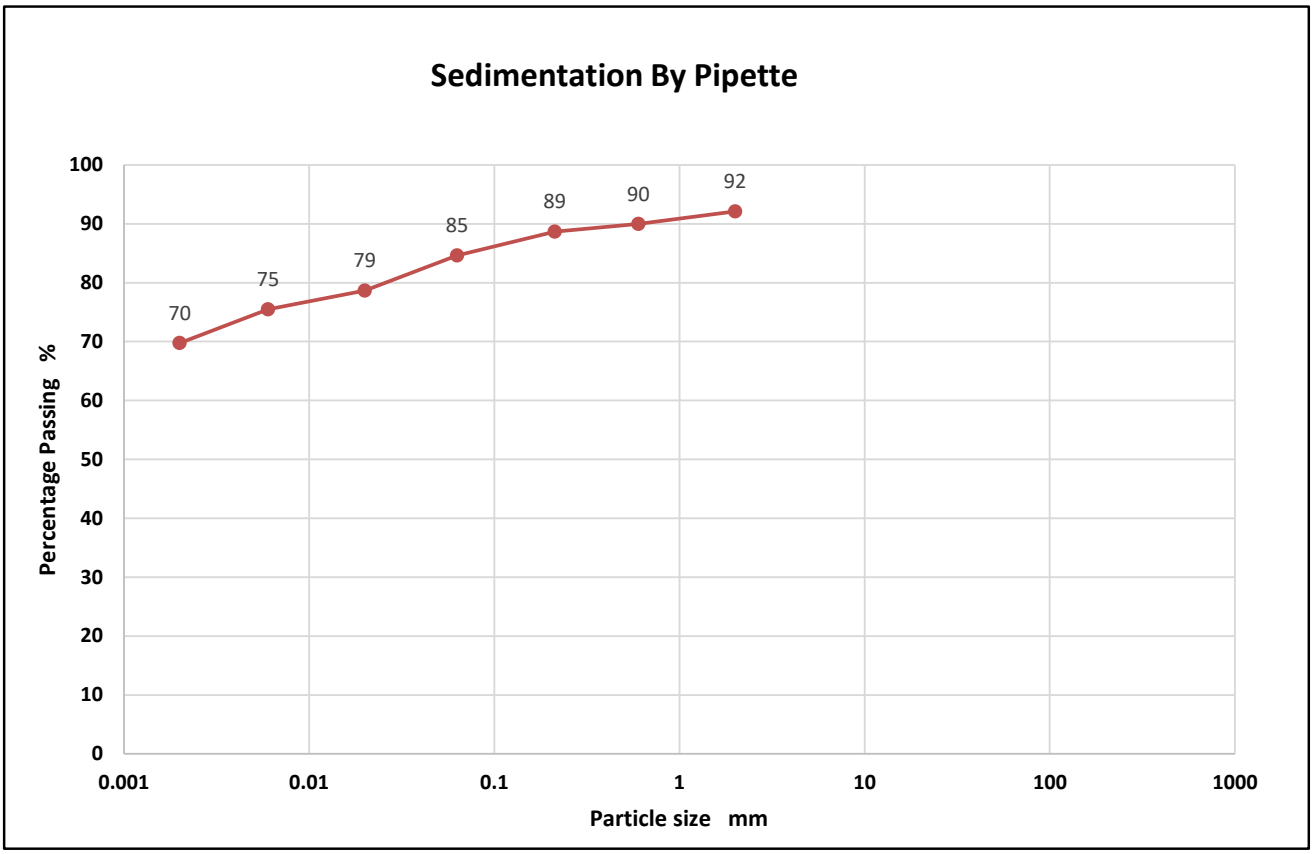
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP12
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	0.50
		Depth Base	1.00
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	92
0.60	90
0.212	89
0.063	85

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	79
0.006	75
0.002	70

Soil Fraction	Total Percentage
Gravel	8
Sand	7
Silt	15
Clay	70

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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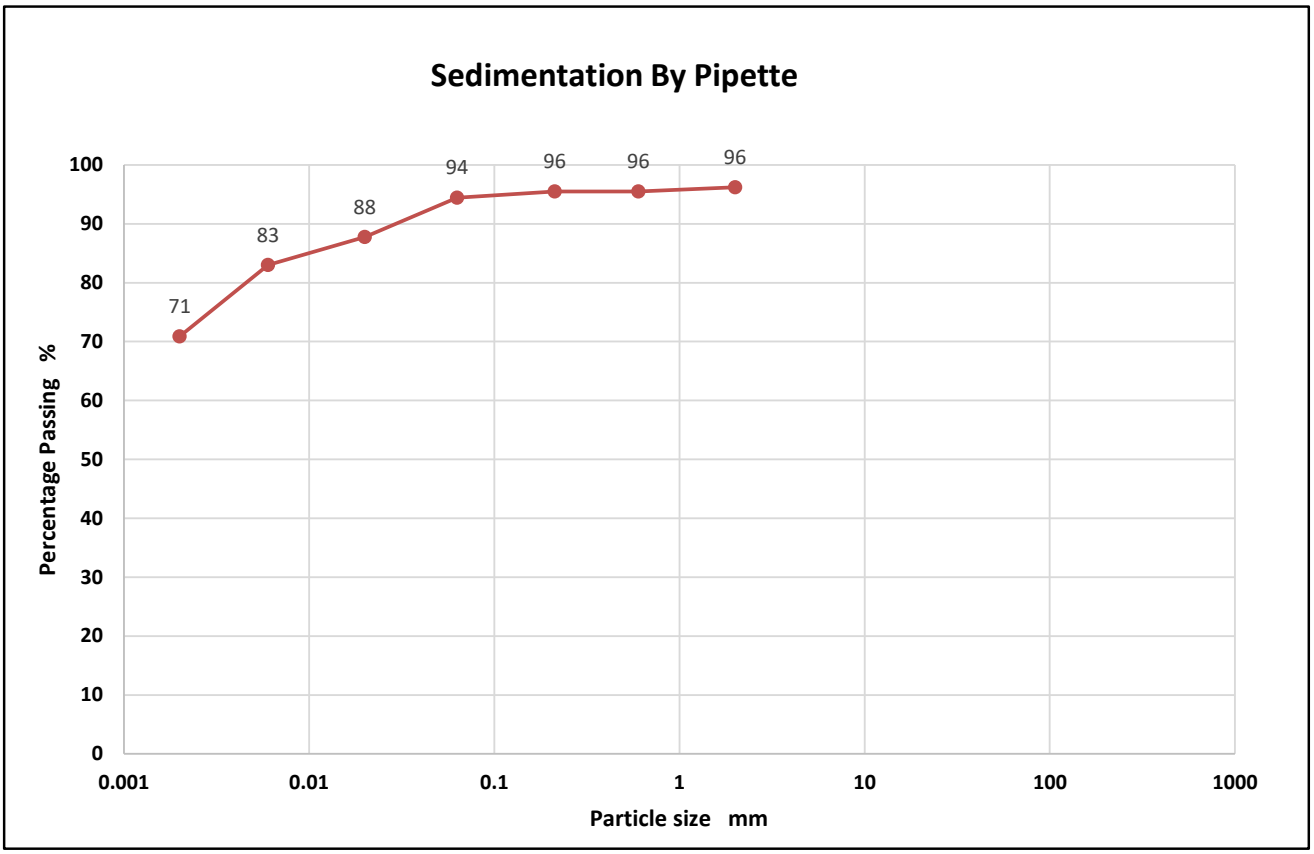
GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46614
		Borehole/Pit No.	RCETP12
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown sandy, fine to medium gravelly, silty CLAY	Depth Top	3.00
		Depth Base	3.25
		Sample Type	LB



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	96
0.212	96
0.063	94

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	88
0.006	83
0.002	71

Soil Fraction	Total Percentage
Gravel	4
Sand	2
Silt	24
Clay	71

Operators	Checked	10/12/2019	Wayne Honey	W. Honey
RO	Approved	11/12/2019	Paul Evans	D P Evans

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GSTL	Certificate of Chemical Analysis (BRE BR 279)	Contract Number	46614
		Client Reference	Q0083
Client	Quantum	Date Received	
Site Name	A40 RCE	Date Started	25/11/2019
		Date Completed	11/12/2019
		No. of Samples	12

Hole Number	Sample Number	Sample Type	Depth (m)			Acid Soluble Sulphate	Aqueous Extract Sulphate	Chloride Content	pH Value	Total Sulphur	Magnesium	Nitrate
RCEBH02	5	B	1.20	-	2.00	0.25	0.04		6.98	0.10		
RCEBH05	2	B	0.50	-	1.00	0.45	0.04		7.28	0.17		
RCEBH07	5	D	1.65	-	1.70	0.27	0.03		7.48	0.11		
RCEBH08	2	B	0.50	-	1.00	0.27	0.03		7.33	0.11		
RCEBH08	10	B	2.70	-	3.00	0.31	0.04		7.49	0.13		
RCEBH09	5	B	1.60	-	2.00	0.31	0.03		7.16	0.13		
RCEBH15	2	B	0.50	-	1.00	0.29	0.04		7.52	0.12		
RCEBH04	5	B	1.20	-	1.50	0.21	0.04		7.40	0.09		
RCEBH06	5	D	1.65	-	1.70	0.31	0.03		7.27	0.13		
RCEBH12	2	B	0.60	-	0.80	0.33	0.04		7.41	0.14		
RCEBH13	3	B	1.00	-		0.35	0.04		7.86	0.14		
RCEBH14	2	B	0.50	-	1.00	0.29	0.04		7.39	0.12		
				-								
				-								
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Key

Reported As
% SO_4
g/l SO_4
mg Cl/l
@ 25°
% S
g/l SO_4
NO_3 mg/l

Remarks

NCP = No Chloride Present

Test Operator	Checked and Authorised by		Paul Evans	D P Evans
Darren Bourne	Date	11/12/2019		

GSTL	Certificate of Chemical Analysis BS1377 Part 3 1990	Contract Number	46614
		Client Reference	Q0083
Client	Quantum	Date Received	
Site Name	A40 RCE	Date Started	25/11/2019
		Date Completed	11/12/2019
		No. of Samples	18

Hole Number	Sample Number	Sample Type	Depth (m)			Acid Soluble Sulphate	Aqueous Extract Sulphate	Water Soluble Chloride	PH Value	Organic Matter Content	Acid Soluble Chloride	Loss On Ignition
RCEBH05	9	D	2.45	-	2.50							4.7
RCEBH05	15	B	3.50	-	4.00					1.5		
RCEBH07	13	D	3.45	-	3.50					1.2		
RCEBH07	15	B	3.50	-	4.00							2.9
RCEBH08	10	B	2.70	-	3.00							7.9
RCEBH09	2	B	0.50	-								3.8
RCEBH09	8	B	2.10	-	2.50					1.6		
RCEBH06	5	D	1.65	-	1.70					1.9		
RCEBH06	9	D	2.45	-	2.50							2.8
RCEBH06	13	D	3.45	-	3.50					1.3		
RCEBH06	15	B	3.50	-	4.00							4
RCETP08	7	LB	3.50	-	4.00					1.7		5.4
RCETP09	3	LB	0.50	-	1.00					1.3		3.9
RCETP09	5	LB	1.50	-	2.00					1.9		5.2
RCETP10	3	LB	0.50	-	1.00					1.1		4.2
RCETP18	3	LB	0.50	-	1.00					1.4		4.6
RCETP03	3	LB	0.50	-	1.00					1.6		3.9
RCETP12	3	LB	0.50	-	1.00					1.2		3.6
				-								
				-								
				-								
				-								
				-								
				-								
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				-								
				-								
				-								
				-								

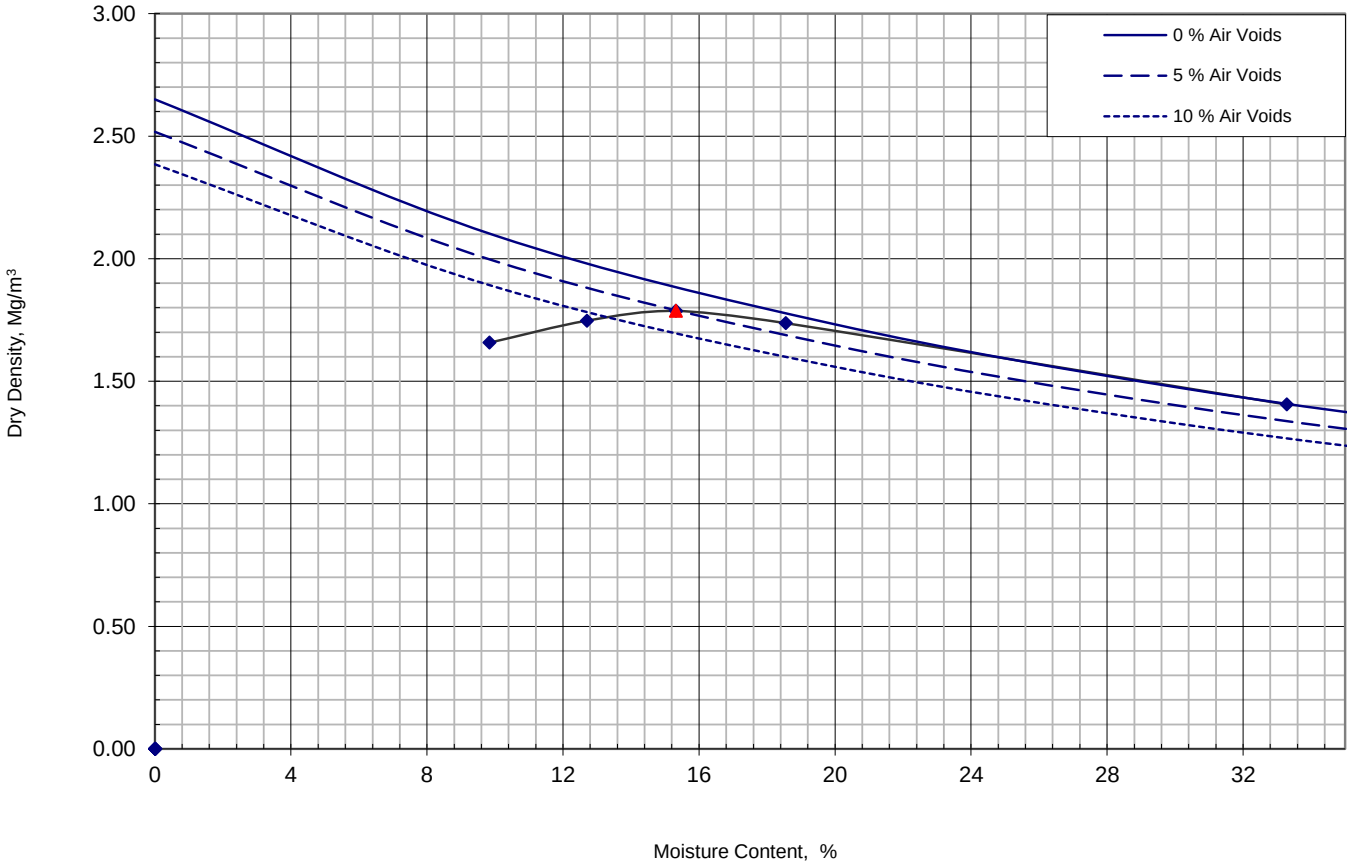
Key	Reported As	Clause
Acid Soluble Sulphate	% SO_3	Clause 5.2 & 5.5
Aqueous Extract Sulphate	g/l SO_3	Clause 5.3 & 5.5
Water Soluble Chloride	%	Clause 7.2
pH Value	@ 25°	Clause 9.5
Organic	%	Clause 3
Acid Soluble Chloride	%	Clause 7.3
LOI	%	Clause 4

Remarks

NCP = No Chloride Present

Test Operator	Checked and Authorised by		Paul Evans	D P Evans
Darren Bourne	Date	11/12/2019		

GSTL	Dry Density / Moisture Content Relationship BS 1377:Part 4:1990	Contract Number	46614
		Borehole / Pit No	RCE-TP05
Project Location	**A40 RCE**	Sample No	**3**
Date Tested	**28/11/2019**	Depth Top	**0.50**
Compaction Method	**2.5 Kg Rammer**	Depth Base	**0.60**
Compaction Clause	**BS1377:Part 4:1990, Clause 3.3**	Sample Type	**B**
Sample Description	**Brown fine to coarse gravelly silty CLAY.**		



Compaction Point	1	2	3	4	5							
Moisture Content	9.8	13	15	19	33							
Bulk Density	1.82	1.97	2.06	2.06	1.87							
Dry Density	1.66	1.75	1.79	1.74	1.41							

Initial Moisture Content	9.8	%
Maximum Dry Density	1.79	Mg/m3
Optimum Moisture Content	15	%
Particle Density	2.65 Assumed	Mg/m3
Material Retained 37.5mm		%
Material Retained 20mm		%

Operators	Checked	10/12/2019	Emma Sharp	
CA	Approved	11/12/2019	Paul Evans	

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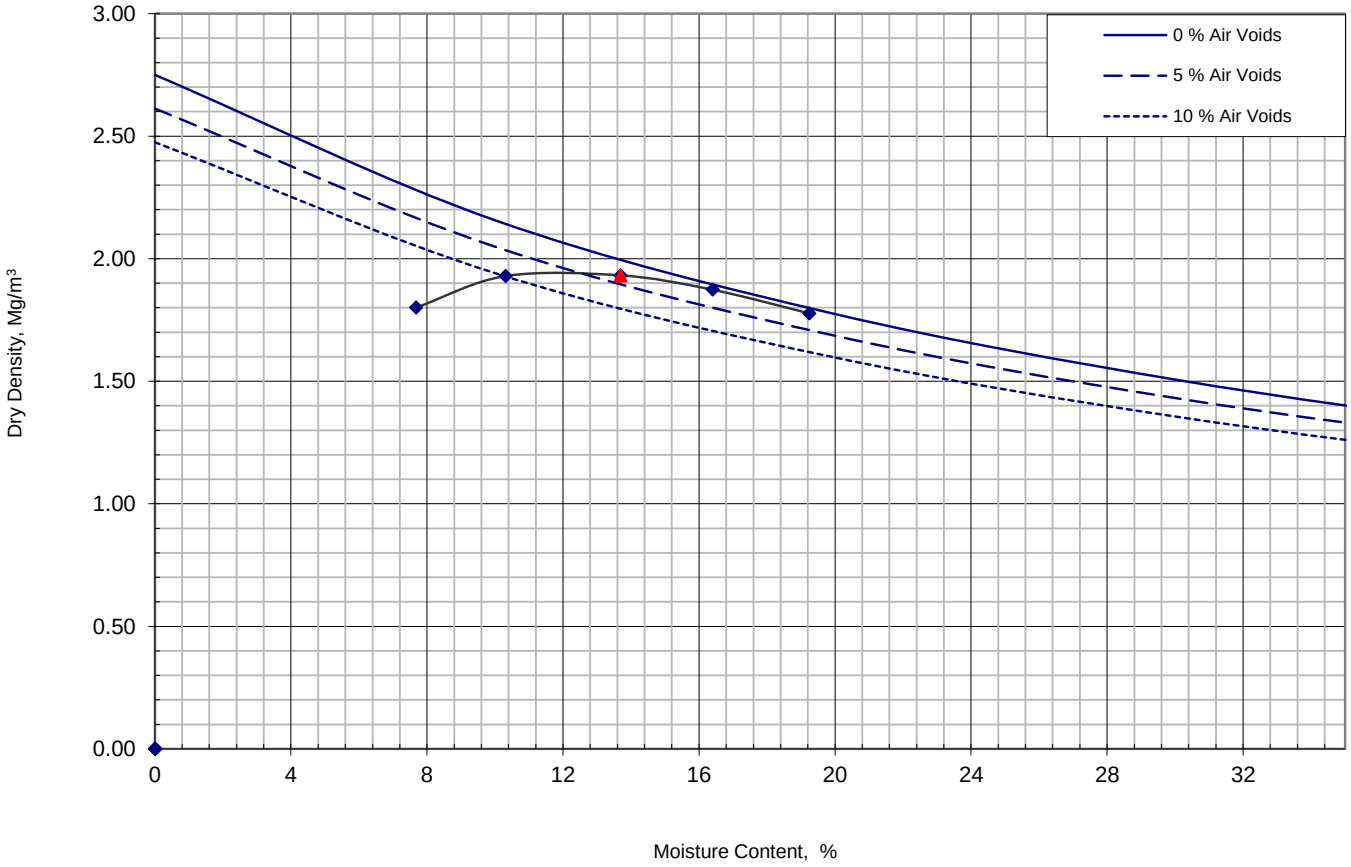
GSTL	Dry Density / Moisture Content Relationship BS 1377:Part 4:1990	Contract Number	46614
		Borehole / Pit No	RCE-TP05
Project Location	**A40 RCE**	Sample No	**5**
Date Tested	**28/11/2019**	Depth Top	**1.00**
Compaction Method	**2.5 Kg Rammer**	Depth Base	**1.10**
Compaction Clause	**BS1377:Part 4:1990, Clause 3.3**	Sample Type	**B**
Sample Description	**Brown fine to coarse gravelly silty CLAY.**		



Compaction Point	1	2	3	4	5							
Moisture Content	7.7	10	14	16	19							
Bulk Density	1.94	2.13	2.20	2.18	2.12							
Dry Density	1.80	1.93	1.93	1.87	1.78							

Initial Moisture Content	7.7	%
Maximum Dry Density	1.93	Mg/m3
Optimum Moisture Content	14	%
Particle Density	2.75 Assumed	Mg/m3
Material Retained 37.5mm	8	%
Material Retained 20mm	70	%

Operators	Checked	10/12/2019	Emma Sharp	
CA	Approved	11/12/2019	Paul Evans	

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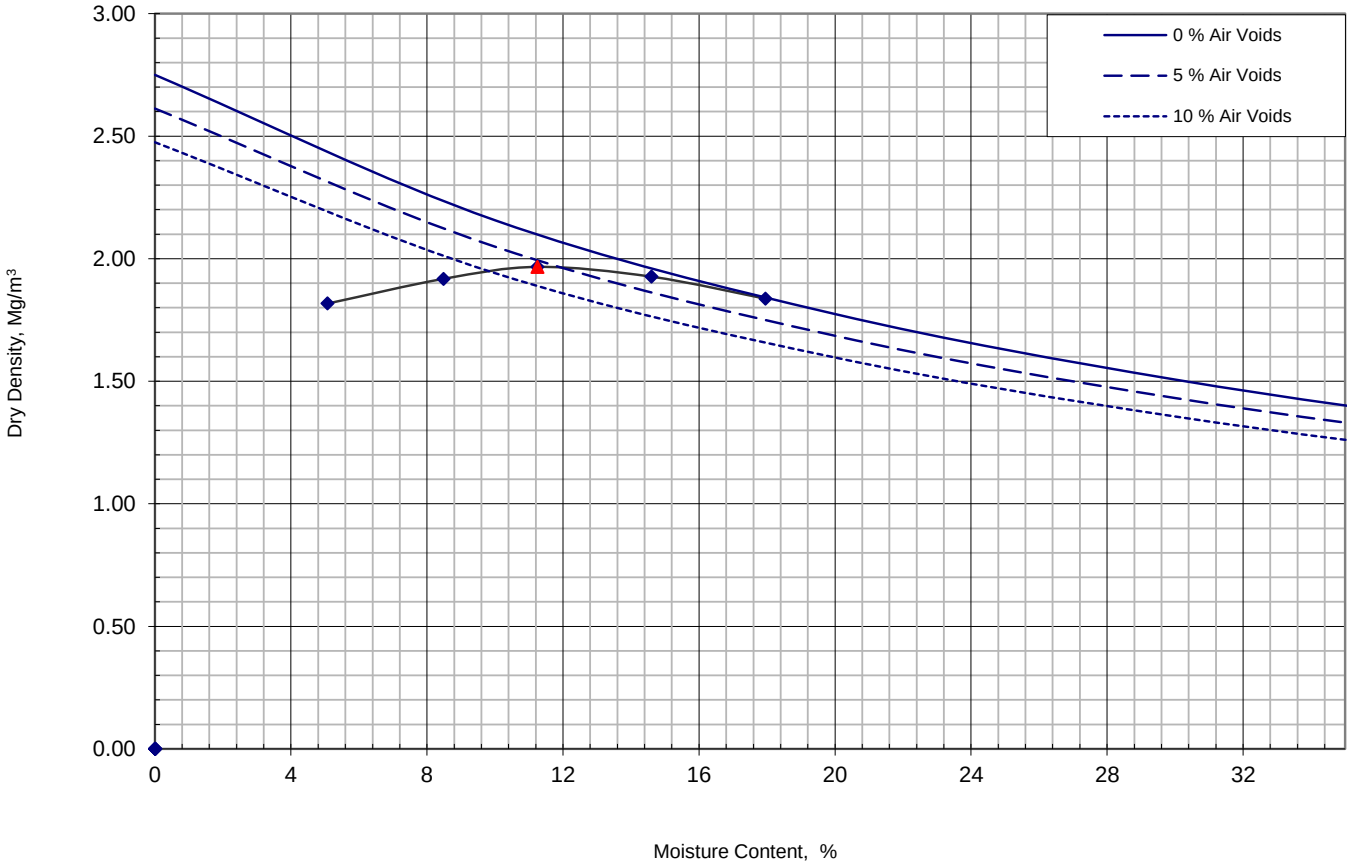
GSTL	Dry Density / Moisture Content Relationship BS 1377:Part 4:1990	Contract Number	46614
		Borehole / Pit No	RCE-TP15
Project Location	**A40 RCE**	Sample No	**5**
Date Tested	**28/11/2019**	Depth Top	**1.50**
Compaction Method	**2.5 Kg Rammer**	Depth Base	**1.70**
Compaction Clause	**BS1377:Part 4:1990, Clause 3.3**	Sample Type	**B**
Sample Description	**Brown fine to coarse gravelly silty CLAY.**		



Compaction Point	1	2	3	4	5							
Moisture Content	5.1	8.5	11	15	18							
Bulk Density	1.91	2.08	2.19	2.21	2.17							
Dry Density	1.82	1.92	1.97	1.93	1.84							

Initial Moisture Content	5.1	%
Maximum Dry Density	1.97	Mg/m3
Optimum Moisture Content	11	%
Particle Density	2.75 Assumed	Mg/m3
Material Retained 37.5mm	0	%
Material Retained 20mm	4	%

Operators	Checked	10/12/2019	Emma Sharp	
CA	Approved	11/12/2019	Paul Evans	

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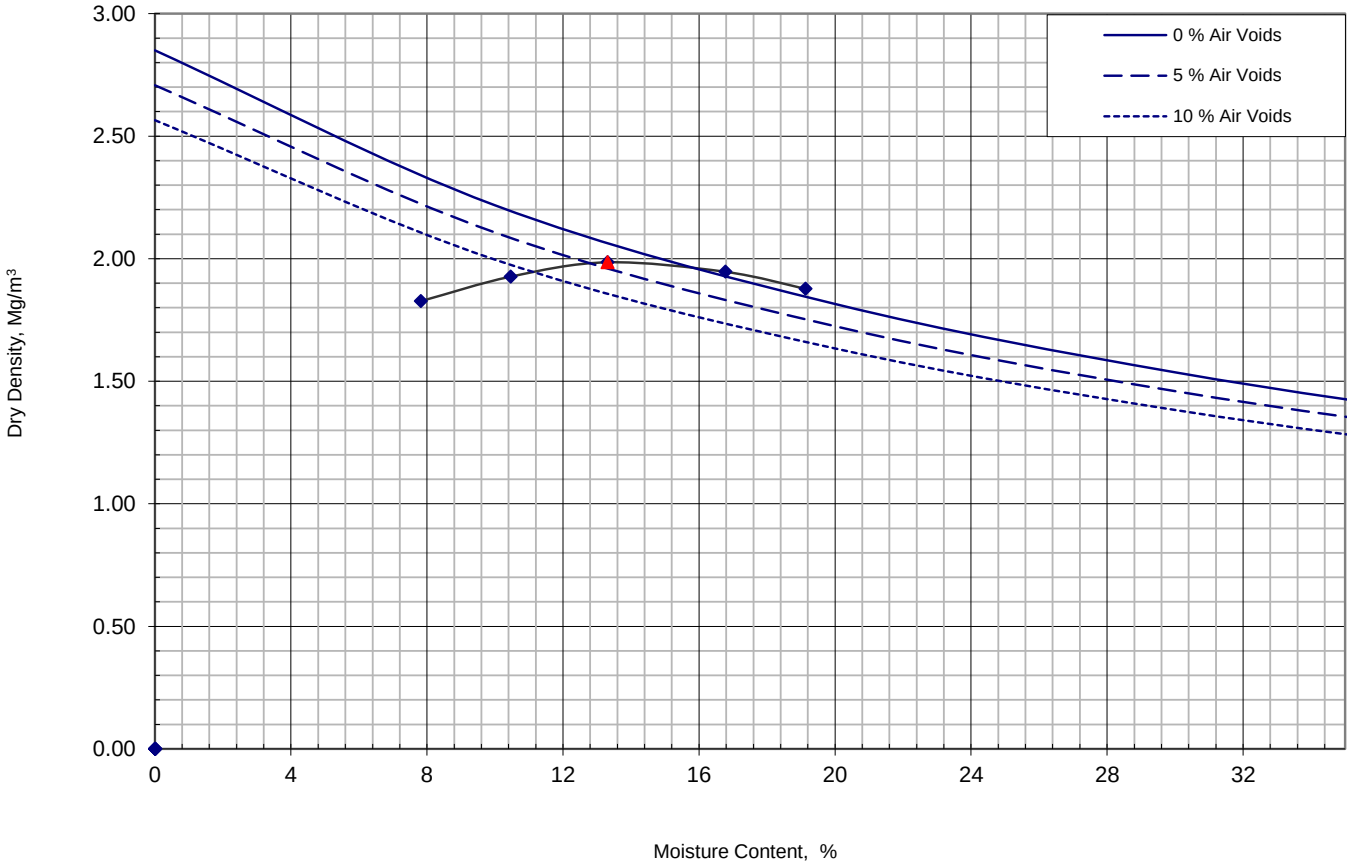
GSTL	Dry Density / Moisture Content Relationship BS 1377:Part 4:1990	Contract Number	46614
		Borehole / Pit No	RCE-TP18
Project Location	**A40 RCE**	Sample No	**5**
Date Tested	**28/11/2019**	Depth Top	**1.50**
Compaction Method	**2.5 Kg Rammer**	Depth Base	**2.00**
Compaction Clause	**BS1377:Part 4:1990, Clause 3.3**	Sample Type	**B**
Sample Description	**Brown fine to coarse gravelly silty CLAY.**		



Compaction Point	1	2	3	4	5							
Moisture Content	7.8	10	13	17	19							
Bulk Density	1.97	2.13	2.25	2.27	2.24							
Dry Density	1.83	1.93	1.99	1.95	1.88							

Initial Moisture Content	7.8	%
Maximum Dry Density	1.99	Mg/m3
Optimum Moisture Content	13	%
Particle Density	2.85 Assumed	Mg/m3
Material Retained 37.5mm	5	%
Material Retained 20mm	39	%

Operators	Checked	10/12/2019	Emma Sharp	
CA	Approved	11/12/2019	Paul Evans	

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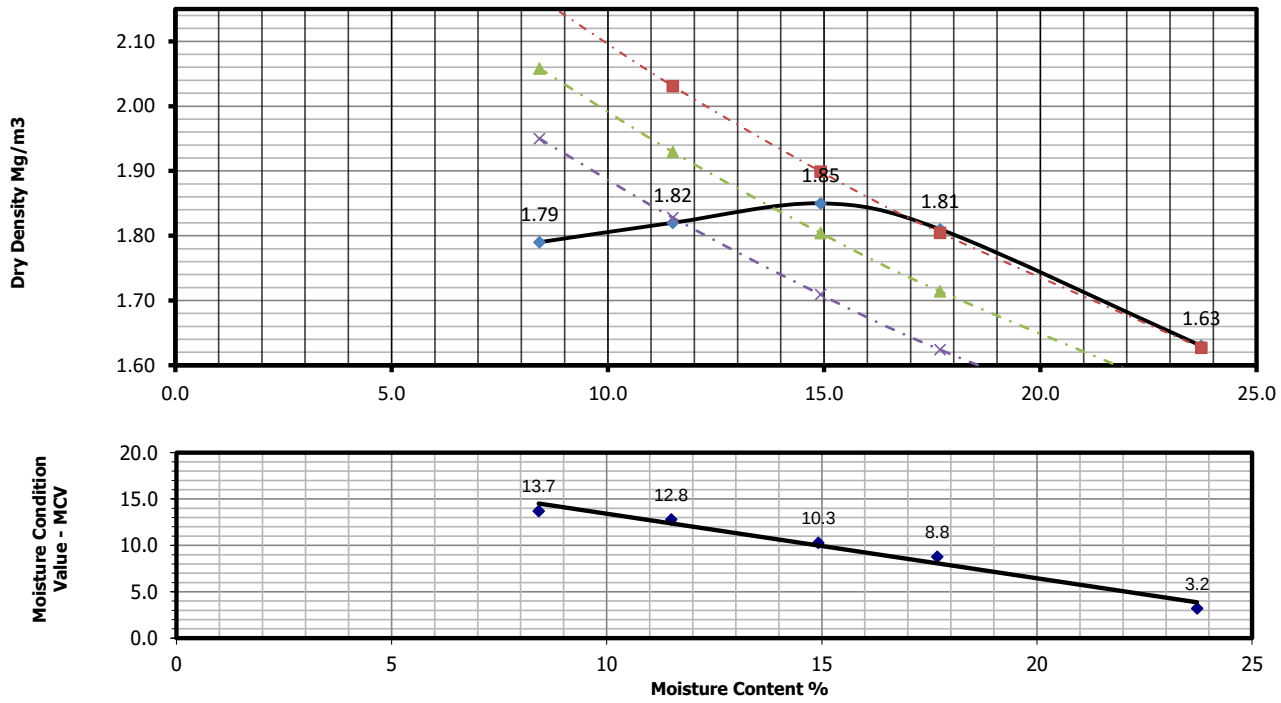
Test Report: **Determination of the MCV Moisture Value & Moisture Content Dry Density Relationship**
BS 1377: Part 4: 1990 Clause 7/5.5/3.3-3.6

Location:	**A40 RCE**
Contract Number:	**46614**
Date tested:	**N/A**
Hole Number:	**RCE-TP03**
Sample Number:	**3**
Depth (m) : From	**0.50**
Depth (m) : To	**1.00**
Sample Type :	**B**
Tested By:	



Moisture Content	8.42	11.5	14.92	17.7	23.7
Dry Density	1.79	1.82	1.85	1.63	1.63
Moisture Condition Value	13.7	12.8	10.3	8.8	3.2

Moisture Content (%):
0 % Air voids
5 % Air voids
10% Air voids

* reading unobtainable

Initial Sample Conditions:

Method of Compaction
2.50

Initial Moisture Content (%):	23.72	Particle Density (Mg/m^3) :	
Maximum Dry Density (Mg/m^3) :	1.85	Assumed	2.65
Material Retained on the 37.5mm BS Sieve (%):	4.3	Single sample Tested	
Material Retained on the 20.0mm BS Sieve (%):	6.8	OMC (%):	14.92

Remarks:

GSTL
GEO SITE & TESTING SERVICES LTD

For and behalf of GEO Site & Testing Services Limited

Emma Sharp - Laboratory Co-Ordinator

Date Approved: 11.12.19

UKAS TESTING
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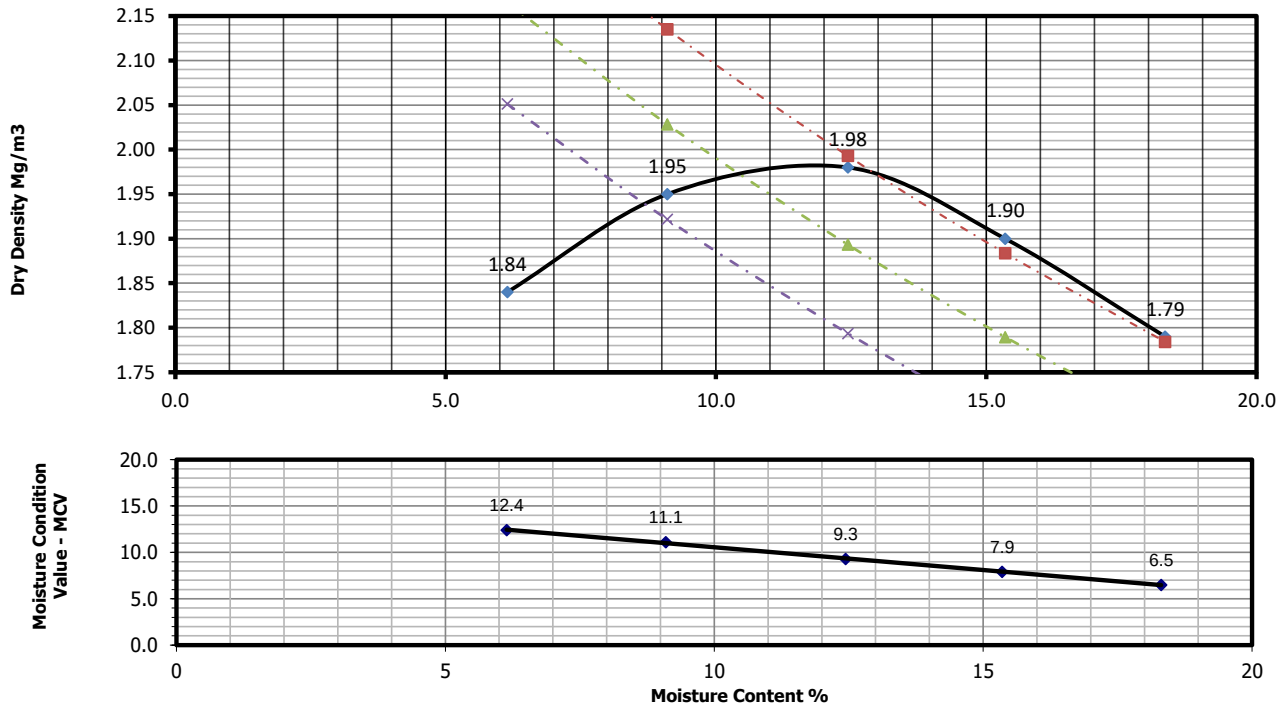
Test Report: **Determination of the MCV Moisture Value & Moisture Content Dry Density Relationship**
BS 1377: Part 4: 1990 Clause 7/5.5/3.3-3.6

Location:	**A40 RCE**
Contract Number:	**46614**
Date tested:	**N/A**
Hole Number:	**RCE-TP05**
Sample Number:	**6**
Depth (m) : From	**2.00**
Depth (m) : To	**2.50**
Sample Type :	**B**
Tested By:	



Moisture Content	6.14	9.1	12.44	15.4	18.3
Dry Density	1.84	1.95	1.98	1.79	1.79
Moisture Condition Value	12.4	11.1	9.3	7.9	6.5

Moisture Content (%):
0 % Air voids
5 % Air voids
10% Air voids

* reading unobtainable

Initial Sample Conditions:

Method of Compaction
2.50

Initial Moisture Content (%):	15.35	Particle Density (Mg/m^3) :	
Maximum Dry Density (Mg/m^3) :	1.98	Assumed	2.65
Material Retained on the 37.5mm BS Sieve (%):	13	Single sample Tested	
Material Retained on the 20.0mm BS Sieve (%):	37	OMC (%):	12.44

Remarks:

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GEO SITE & TESTING SERVICES LTD

For and behalf of GEO Site & Testing Services Limited

Emma Sharp - Laboratory Co-Ordinator

Date Approved: 11.12.19

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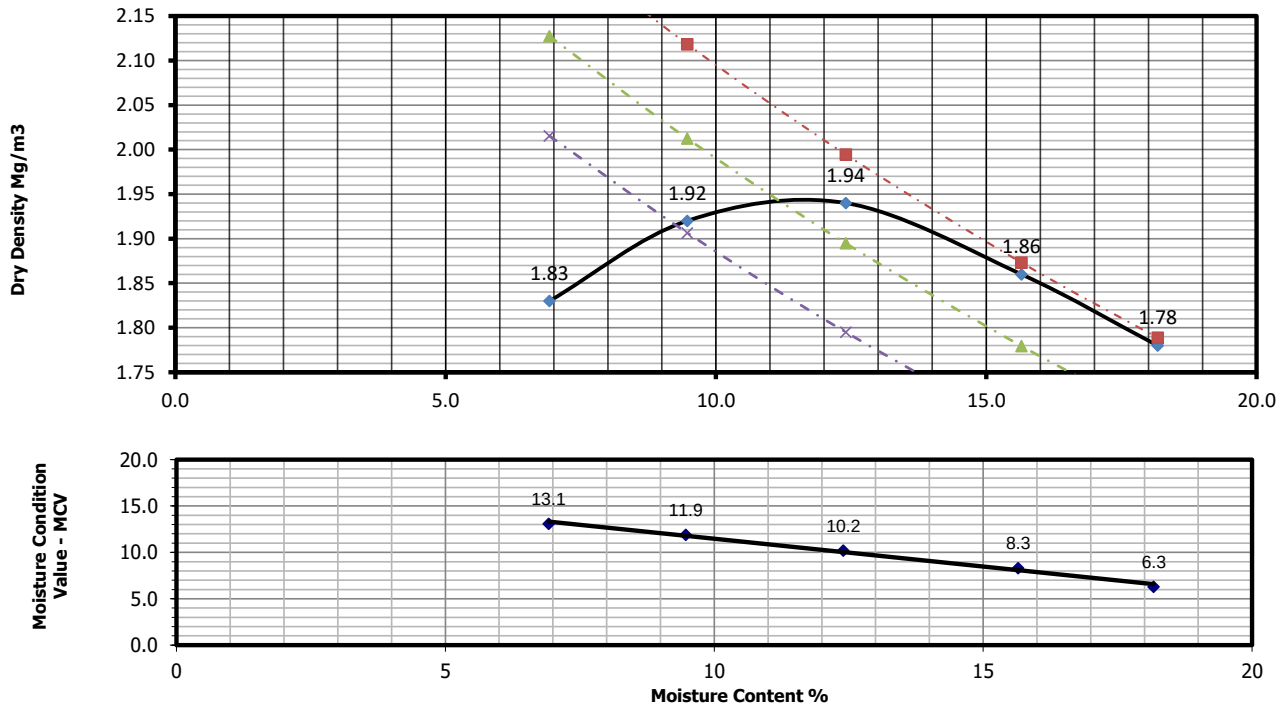
Test Report: **Determination of the MCV Moisture Value & Moisture Content Dry Density Relationship**
BS 1377: Part 4: 1990 Clause 7/5.5/3.3-3.6

Location:	**A40 RCE**
Contract Number:	**46614**
Date tested:	**N/A**
Hole Number:	**RCE-TP06**
Sample Number:	**4**
Depth (m) : From	**0.50**
Depth (m) : To	**1.00**
Sample Type :	**B**
Tested By:	



Moisture Content	6.92	9.47	12.4	15.7	18.2
Dry Density	1.83	1.92	1.94	1.78	1.78
Moisture Condition Value	13.1	11.9	10.2	8.3	6.3

Moisture Content (%):
0 % Air voids
5 % Air voids
10% Air voids

* reading unobtainable

Initial Sample Conditions:

Method of Compaction 2.50

Initial Moisture Content (%):	15.65	Particle Density (Mg/m^3) :	
Maximum Dry Density (Mg/m^3) :	1.94	Assumed	2.65
Material Retained on the 37.5mm BS Sieve (%):	23	Single sample Tested	
Material Retained on the 20.0mm BS Sieve (%):	41	OMC (%):	12.4

Remarks:

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GEO SITE & TESTING SERVICES LTD

For and behalf of GEO Site & Testing Services Limited

Emma Sharp - Laboratory Co-Ordinator

Date Approved: 11.12.19

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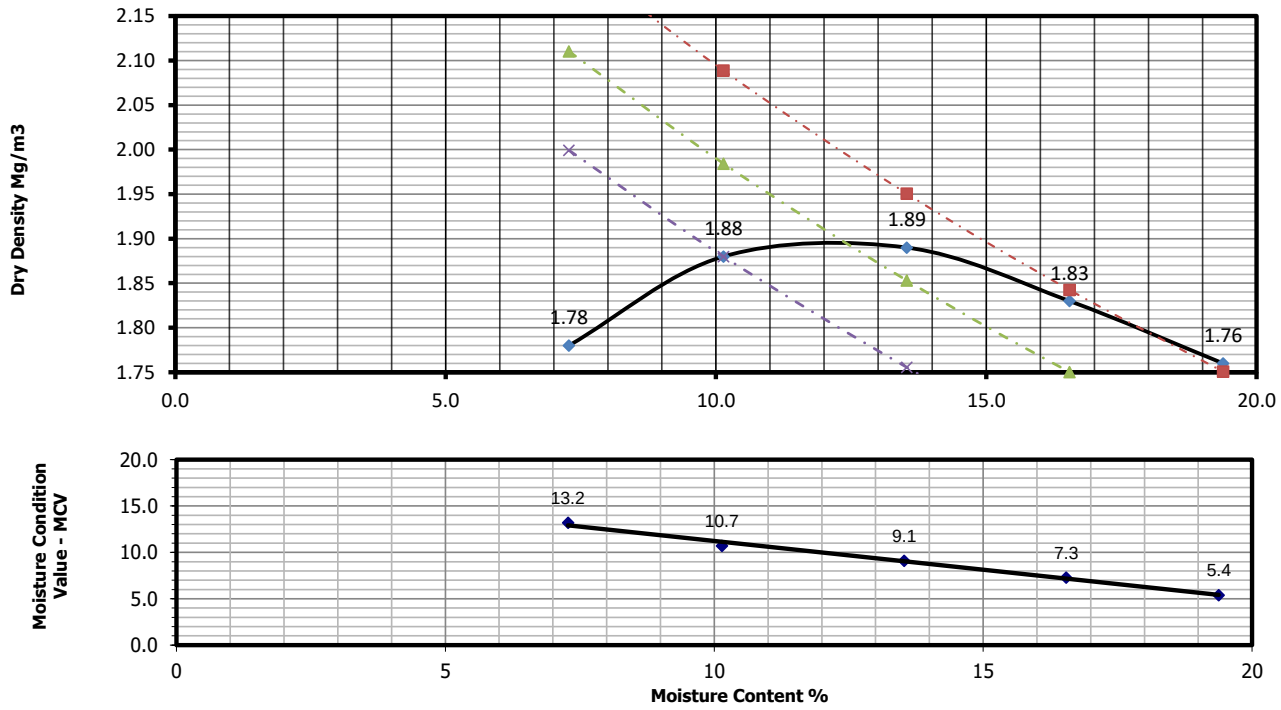
Test Report: **Determination of the MCV Moisture Value & Moisture Content Dry Density Relationship**
BS 1377: Part 4: 1990 Clause 7/5.5/3.3-3.6

Location:	**A40 RCE**
Contract Number:	**46614**
Date tested:	**N/A**
Hole Number:	**RCE-TP15**
Sample Number:	**4**
Depth (m) : From	**0.50**
Depth (m) : To	**1.00**
Sample Type :	**B**
Tested By:	



Moisture Content	7.28	10.14	13.53	16.5	19.4
Dry Density	1.78	1.88	1.89	1.76	1.76
Moisture Condition Value	13.2	10.7	9.1	7.3	5.4

Moisture Content (%):
0 % Air voids
5 % Air voids
10% Air voids

* reading unobtainable

Initial Sample Conditions:

Method of Compaction 2.50

Initial Moisture Content (%):	16.54	Particle Density (Mg/m^3) :	
Maximum Dry Density (Mg/m^3) :	1.89	Assumed	2.65
Material Retained on the 37.5mm BS Sieve (%):	23	Single sample Tested	
Material Retained on the 20.0mm BS Sieve (%):	39	OMC (%):	13.53

Remarks:

GSTL
GEO SITE & TESTING SERVICES LTD

For and behalf of GEO Site & Testing Services Limited

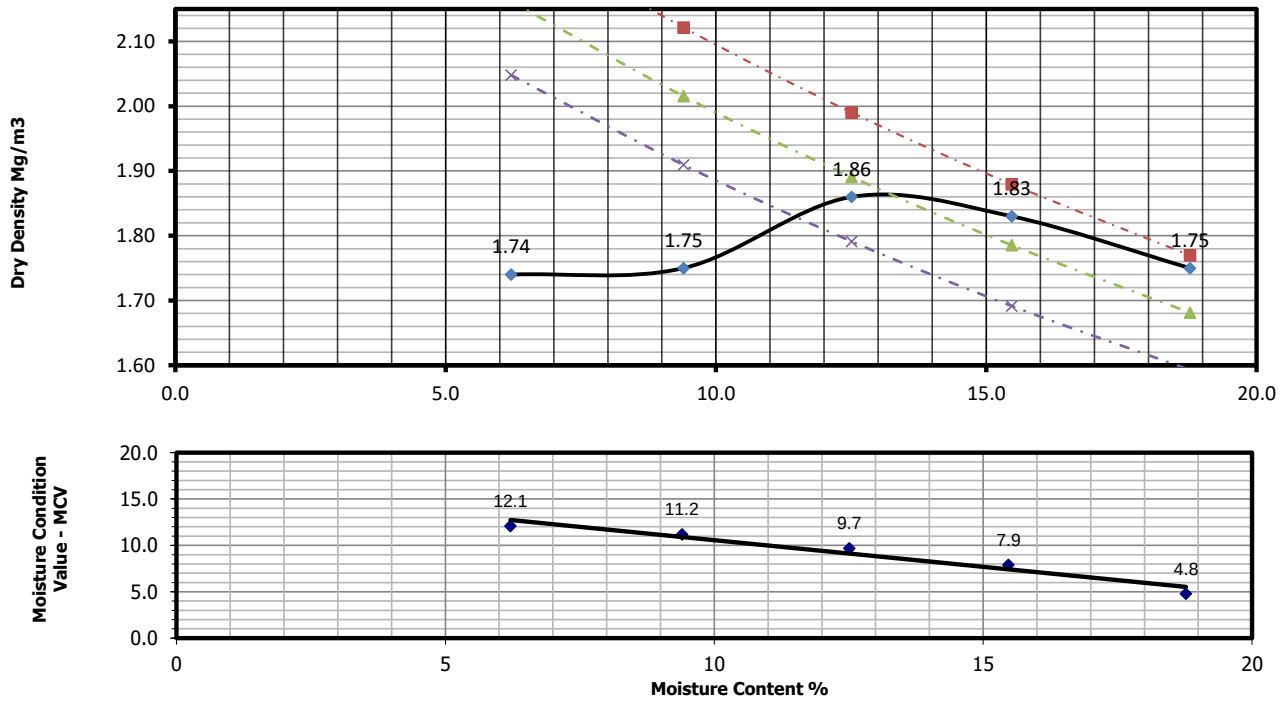
Emma Sharp - Laboratory Co-Ordinator

Date Approved: 11.12.19

UKAS TESTING 2788

Test Report: **Determination of the MCV Moisture Value & Moisture Content Dry Density Relationship**
BS 1377: Part 4: 1990 Clause 7/5.5/3.3-3.6

Location:	**A40 RCE**
Contract Number:	**46614**
Date tested:	**N/A**
Hole Number:	**RCE-TP18**
Sample Number:	**3**
Depth (m) : From	**0.50**
Depth (m) : To	**0.90**
Sample Type :	**B**
Tested By:	



Moisture Content	6.21	9.4	12.51	15.5	18.8
Dry Density	1.74	1.75	1.86	1.75	1.75
Moisture Condition Value	12.1	11.2	9.7	7.9	4.8

Moisture Content (%):
0 % Air voids
5 % Air voids
10% Air voids

* reading unobtainable

Initial Sample Conditions:

Method of Compaction
2.50

Initial Moisture Content (%):	18.77	Particle Density (Mg/m^3) :	
Maximum Dry Density (Mg/m^3) :	1.86	Assumed	2.65
Material Retained on the 37.5mm BS Sieve (%):	0	Single sample Tested	
Material Retained on the 20.0mm BS Sieve (%):	20	OMC (%):	15.51

Remarks:

GSTL
GEO SITE & TESTING SERVICES LTD

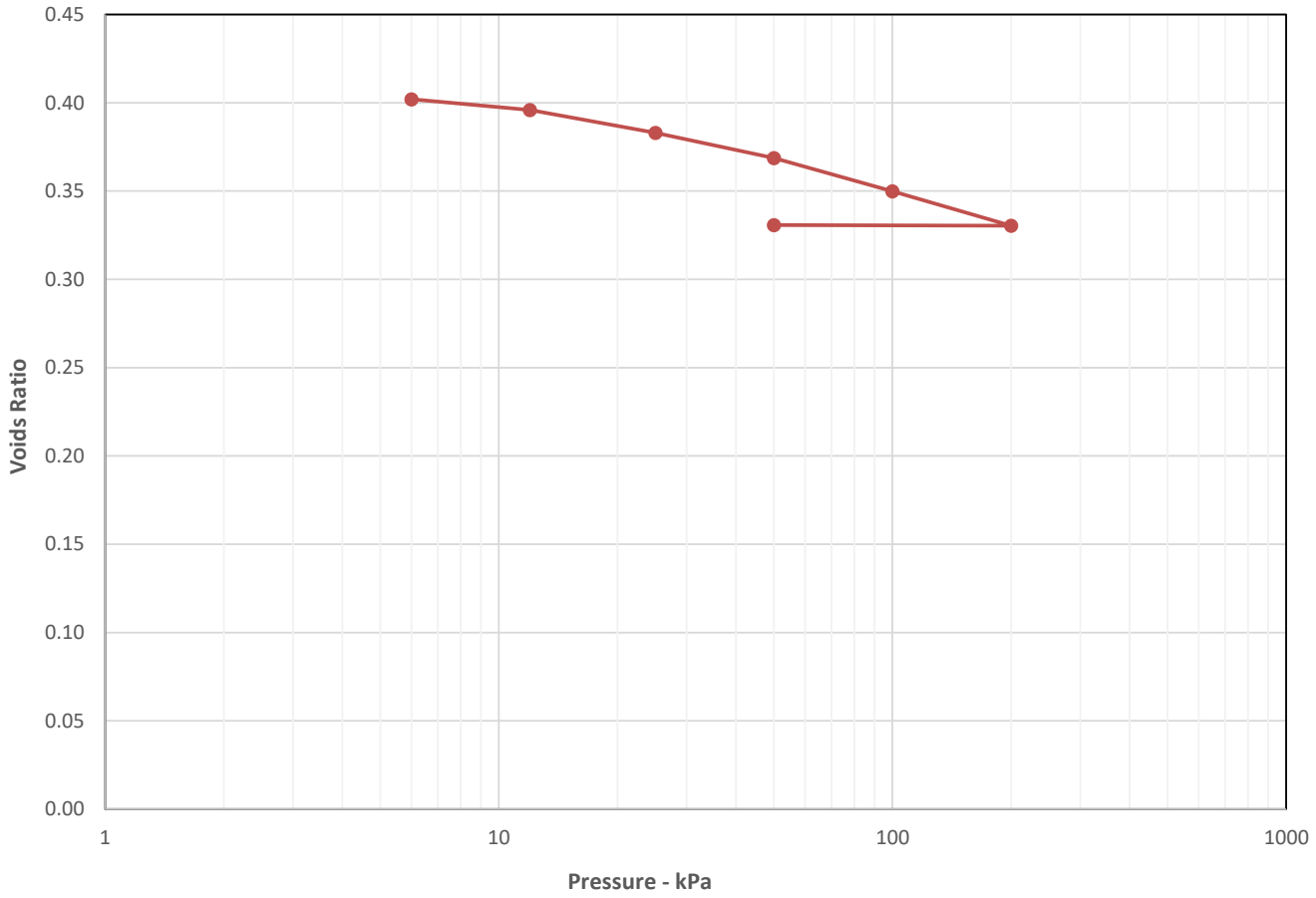
For and behalf of GEO Site & Testing Services Limited

Emma Sharp - Laboratory Co-Ordinator

Date Approved: 11.12.19

UKAS TESTING
2788

GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCEBH05
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine gravelly sandy silty CLAY.	Depth Top (m)	1.20
		Depth Base (m)	1.65
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		

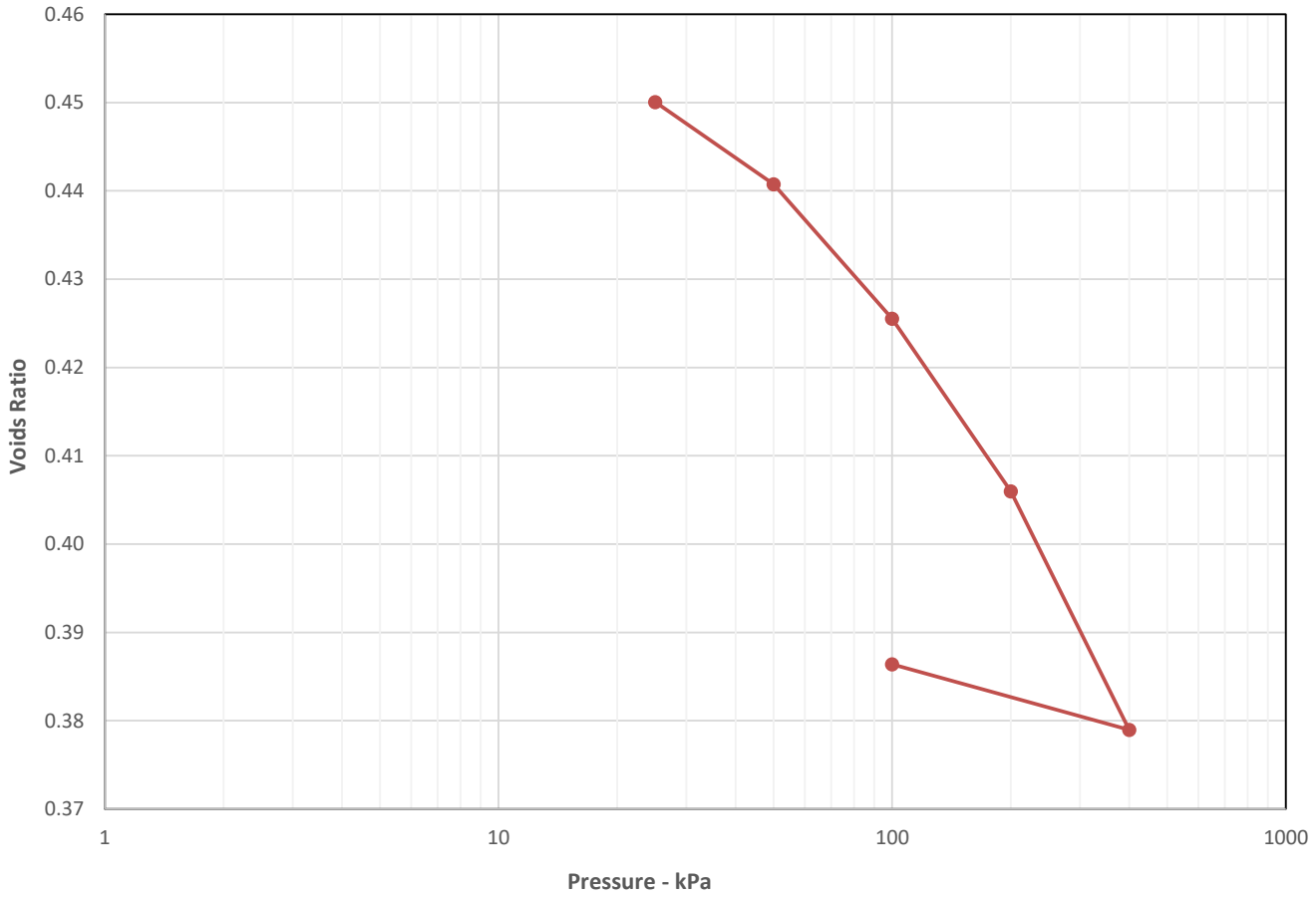


Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	13	0	-	6	0.91	1.2		-			
Bulk Density (Mg/m3)	2.37	6	-	12	0.72	2.8		-			
Dry Density (Mg/m3)	2.09	12	-	25	0.71	6.3		-			
Voids Ratio	0.4098	25	-	50	0.4	9.6		-			
Degree of saturation	94.0	50	-	100	0.27	8.2		-			
Height (mm)	19.68	100	-	200	0.14	8.8		-			
Diameter (mm)	74.6	200	-	50	0.0014	8.6		-			
Particle Density (Mg/m3)	2.95		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
2788

GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCEBH05
Site Name	A40 RCE	Sample No.	12
Soil Description	Brown fine gravelly sandy silty CLAY.	Depth Top (m)	3.00
		Depth Base (m)	3.40
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		



Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	16	0	-	25	0.05	5.6		-			
Bulk Density (Mg/m3)	2.27	25	-	50	0.26	8.9		-			
Dry Density (Mg/m3)	1.96	50	-	100	0.21	8.5		-			
Voids Ratio	0.4519	100	-	200	0.1	13		-			
Degree of saturation	99.9	200	-	400	0.096	6.8		-			
Height (mm)	19.93	400	-	100	0.018	5.4		-			
Diameter (mm)	50.06		-					-			
Particle Density (Mg/m3)	2.85		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
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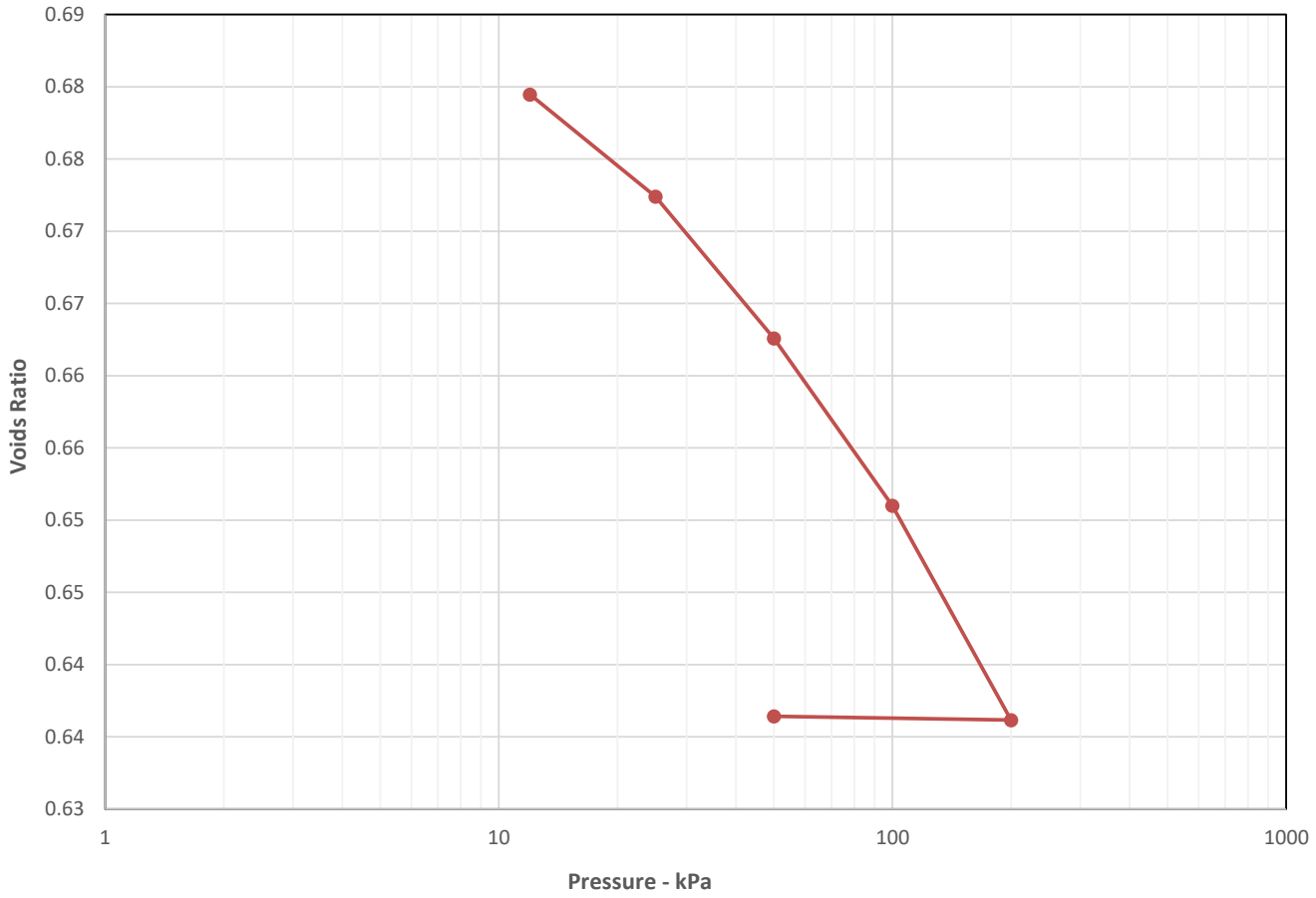
GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCEBH06
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine gravelly sandy silty CLAY.	Depth Top (m)	2.00
		Depth Base (m)	
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		

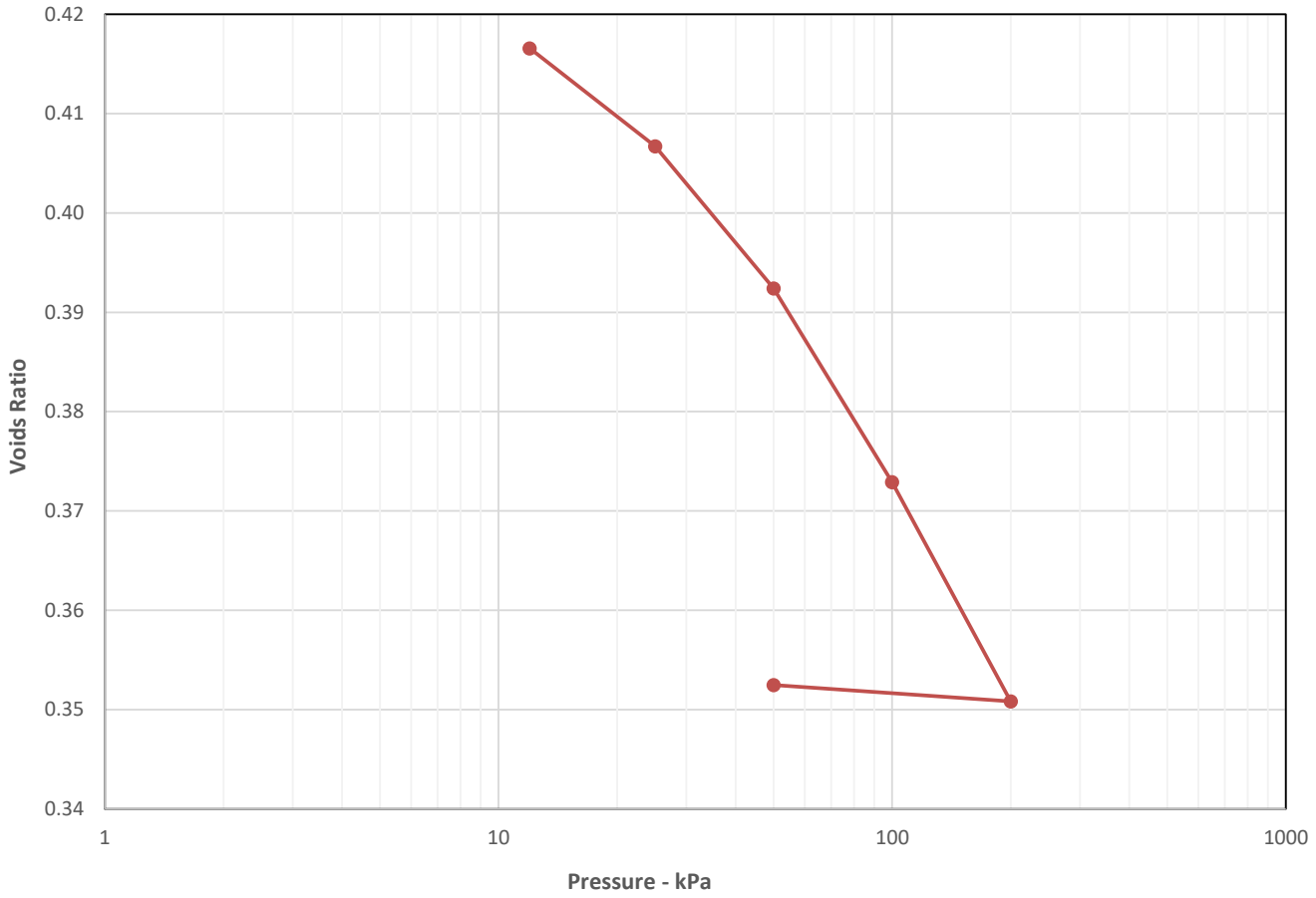


Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	15	0	-	12	0.19	2.7		-			
Bulk Density (Mg/m3)	1.80	12	-	25	0.32	5.4		-			
Dry Density (Mg/m3)	1.57	25	-	50	0.23	8.7		-			
Voids Ratio	0.6833	50	-	100	0.1	10		-			
Degree of saturation	56.8	100	-	200	0.09	8		-			
Height (mm)	19.75	200	-	50	0.001	16		-			
Diameter (mm)	74.6		-					-			
Particle Density (Mg/m3)	2.65		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
2788

GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCEBH07
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine gravelly sandy silty CLAY.	Depth Top (m)	2.00
		Depth Base (m)	2.45
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		



Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	15	0	-	12	0.57	2.1		-			
Bulk Density (Mg/m3)	2.25	12	-	25	0.54	2.7		-			
Dry Density (Mg/m3)	1.95	25	-	50	0.41	5.6		-			
Voids Ratio	0.4263	50	-	100	0.3	9.7		-			
Degree of saturation	99.9	100	-	200	0.16	9.5		-			
Height (mm)	19.83	200	-	50	0.0082	11		-			
Diameter (mm)	74.9		-					-			
Particle Density (Mg/m3)	2.78		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
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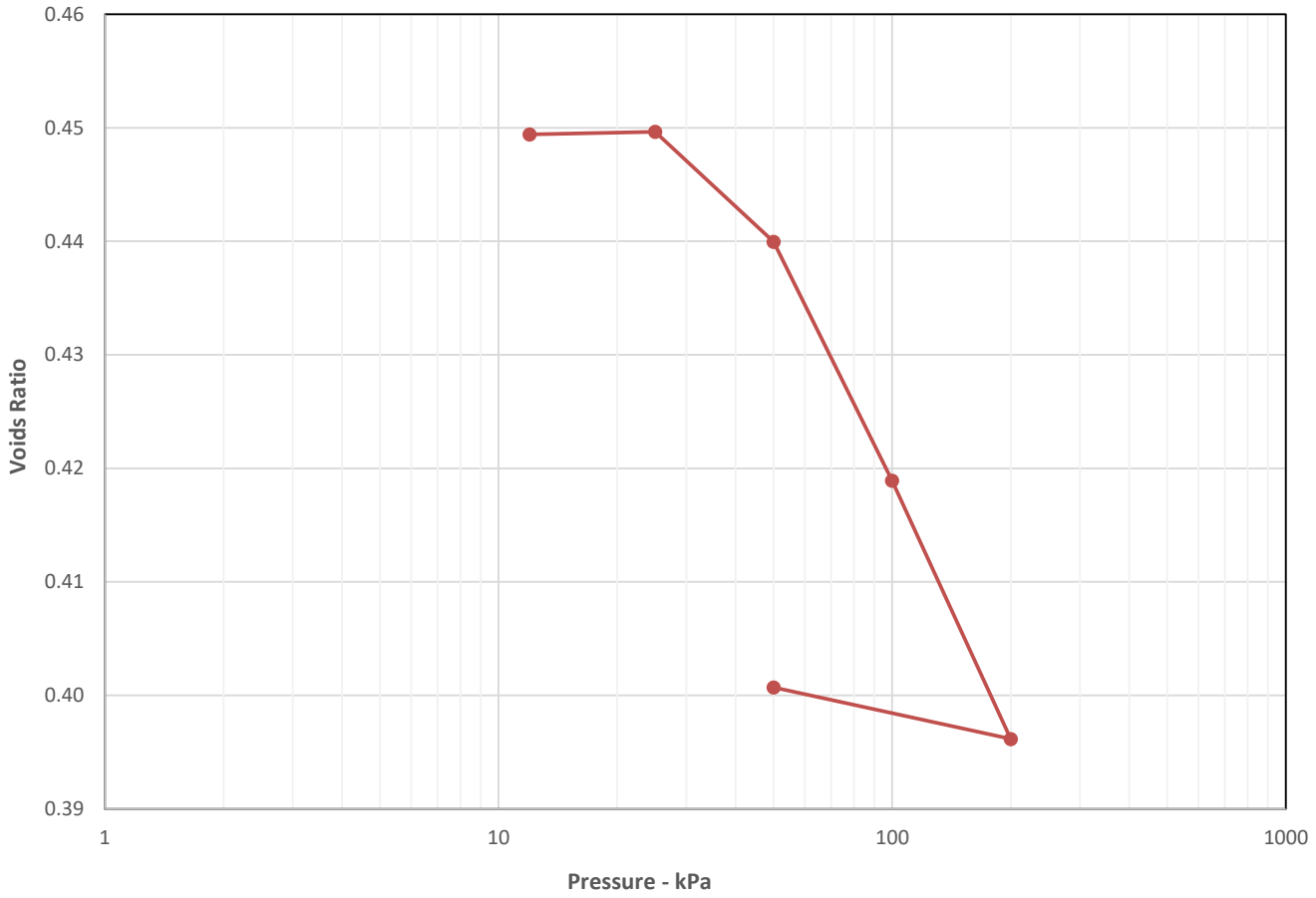
GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCEBH08
Site Name	A40 RCE	Sample No.	7
Soil Description	Greyish brown fine gravelly sandy silty CLAY.	Depth Top (m)	2.20
		Depth Base (m)	2.65
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	27/11/2019		



Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	16	0	-	12	Swell	Stage		-			
Bulk Density (Mg/m3)	2.23	12	-	25	-0.012	4.7		-			
Dry Density (Mg/m3)	1.93	25	-	50	0.27	7.6		-			
Voids Ratio	0.4420	50	-	100	0.3	13		-			
Degree of saturation	99.3	100	-	200	0.16	8.9		-			
Height (mm)	18.77	200	-	50	0.022	12		-			
Diameter (mm)	74.96		-					-			
Particle Density (Mg/m3)	2.78		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
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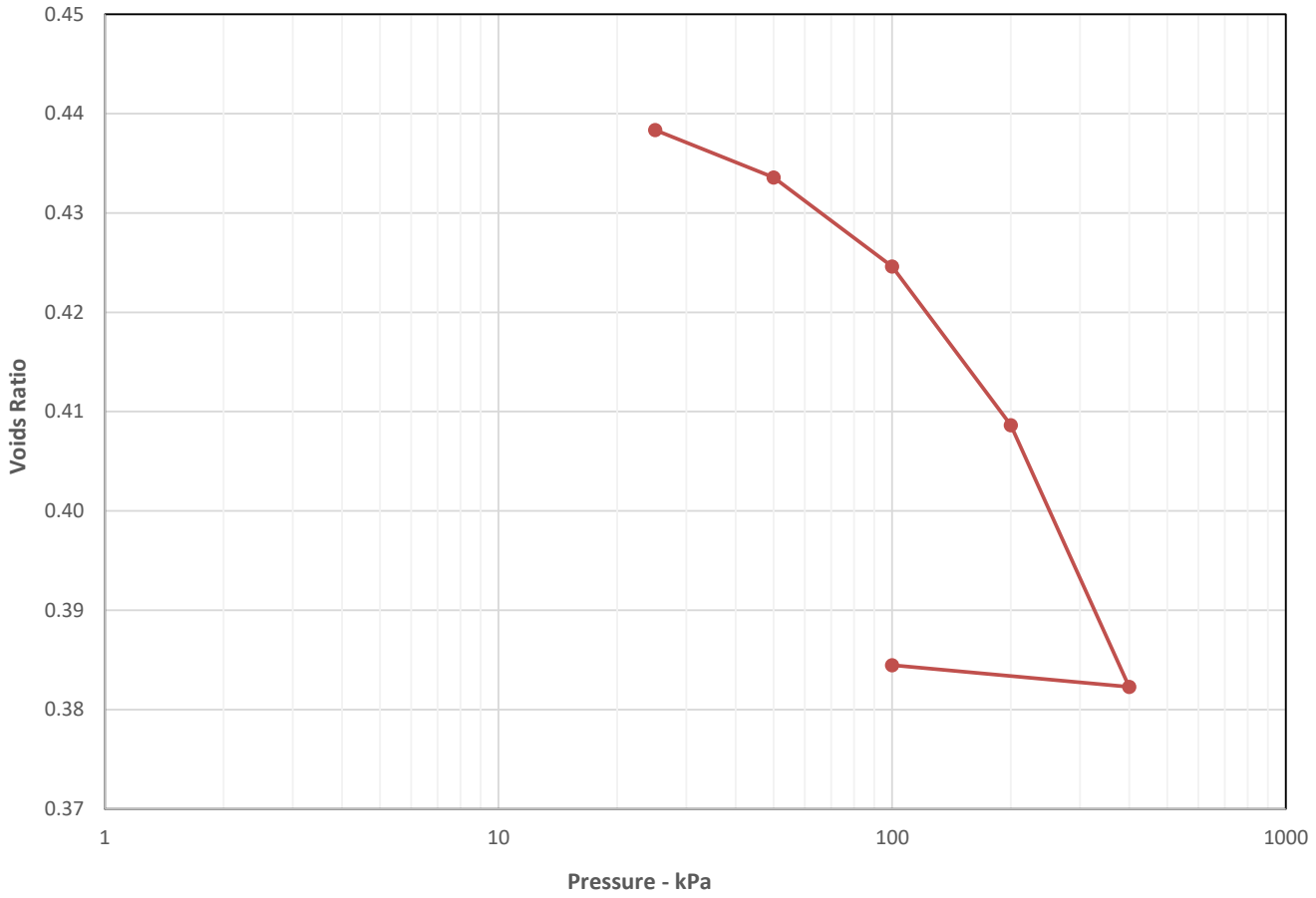
GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCETP08
Site Name	A40 RCE	Sample No.	7
Soil Description	Brown fine gravelly sandy silty CLAY.	Depth Top (m)	3.50
		Depth Base (m)	4.00
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		



Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	17	0	-	25	0.69	110		-			
Bulk Density (Mg/m3)	2.20	25	-	50	0.13	12		-			
Dry Density (Mg/m3)	1.89	50	-	100	0.12	7.7		-			
Voids Ratio	0.4637	100	-	200	0.1	11		-			
Degree of saturation	99.5	200	-	400	0.093	15		-			
Height (mm)	19.95	400	-	100	0.0053	11		-			
Diameter (mm)	49.91		-					-			
Particle Density (Mg/m3)	2.76		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
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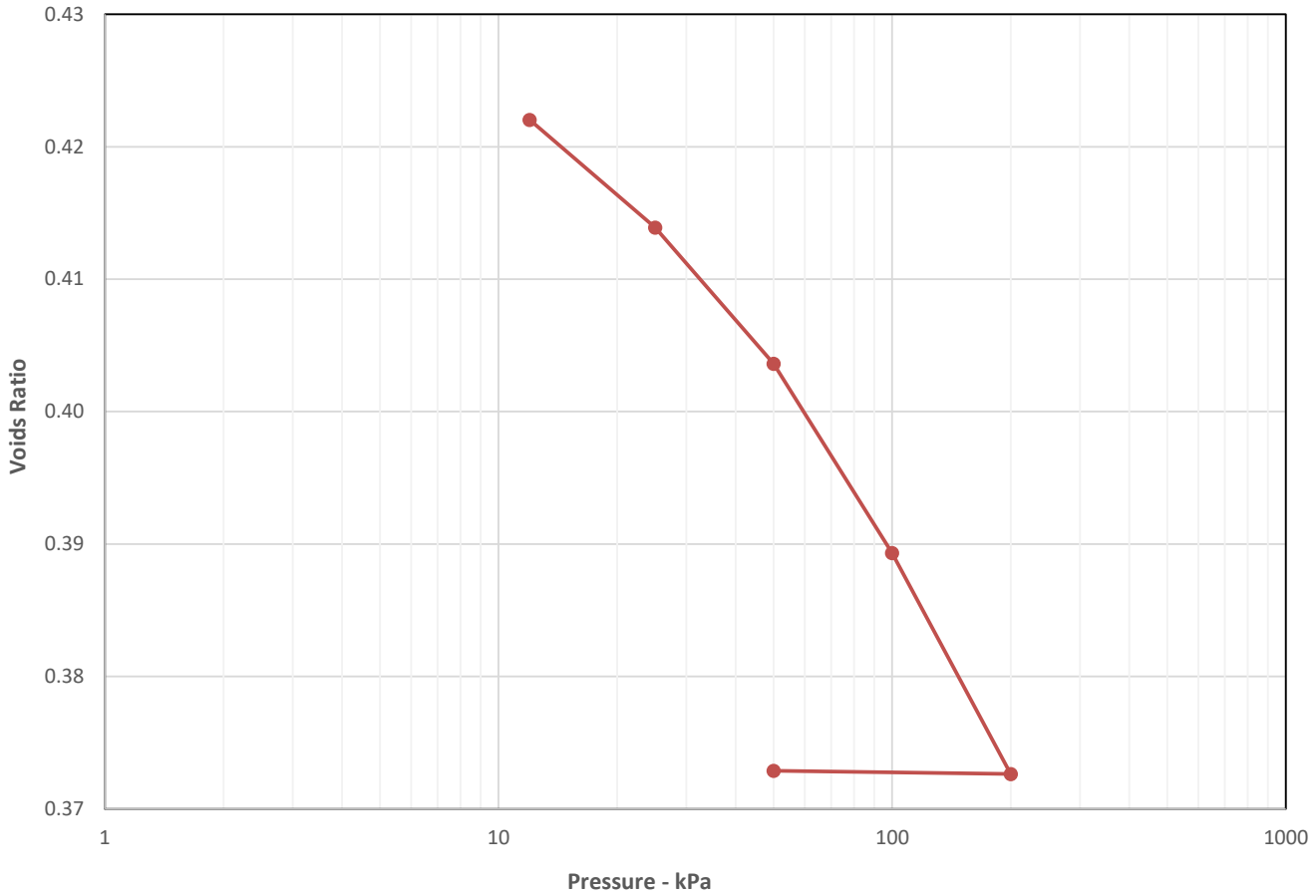
GSTL	ONE DIMENSIONAL CONSOLIDATION TEST BS1377:Part 5:1990, clause 3	Contract Number	46614
		Borehole/Trialpit No.	RCETP09
Site Name	A40 RCE	Sample No.	5
Soil Description	Greyish brown fine gravelly sandy silty CLAY.	Depth Top (m)	1.50
		Depth Base (m)	2.00
Lab Temperature	20°c	Sample Location	Middle
Remarks	Cv Calculated Using T90 Particle Density Assumed Unless Stated Otherwise	Sample Type	U
Date Tested	25/11/2019		

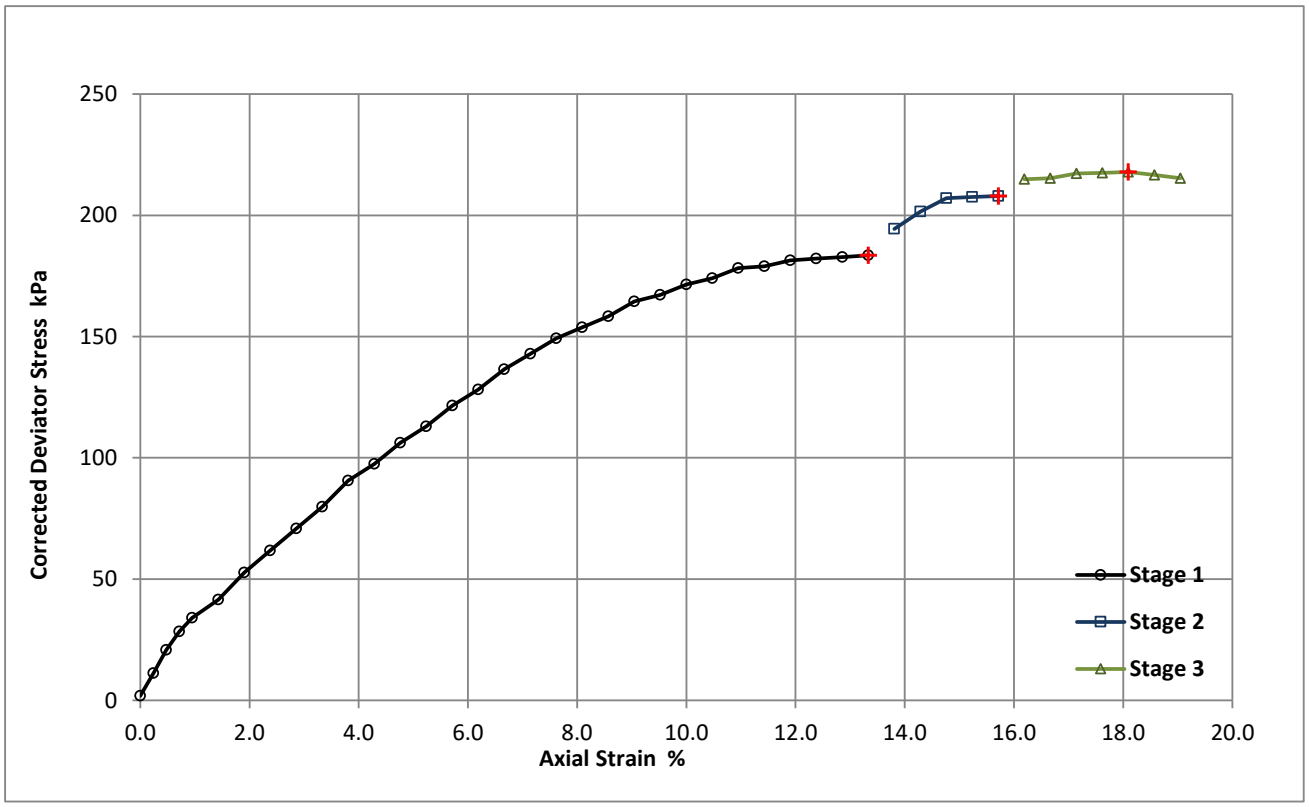


Initial Sample Conditions		Pressure Range			Mv m2/MN	Cv m2/yr	Pressure Range			Mv m2/MN	Cv m2/yr
Moisture Content (%)	16	0	-	12	0.34	2.3		-			
Bulk Density (Mg/m3)	2.20	12	-	25	0.44	1.9		-			
Dry Density (Mg/m3)	1.90	25	-	50	0.29	2.6		-			
Voids Ratio	0.4278	50	-	100	0.2	5.7		-			
Degree of saturation	99.2	100	-	200	0.12	4.8		-			
Height (mm)	18.07	200	-	50	0.0012	8		-			
Diameter (mm)	74.97		-					-			
Particle Density (Mg/m3)	2.71		-					-			

Operators	Checked	10/12/2019	Emma Sharp	
LG	Approved	11/12/2019	Paul Evans	

UKAS TESTING
2788

GSTL	Multi Stage Unconsolidated-Undrained Triaxial Test BS 1377 : 1990 Part 7 : 9	Contract Number	46614
		Borehole/Pit No.	RCE-BH05
Site Name	A40 RCE	Sample No.	8
Soil Description	Brown fine to coarse gravelly sandy silty CLAY.	Depth Top	2.00
		Depth Base	2.45
Date Tested	27/11/2019	Sample Type	UT



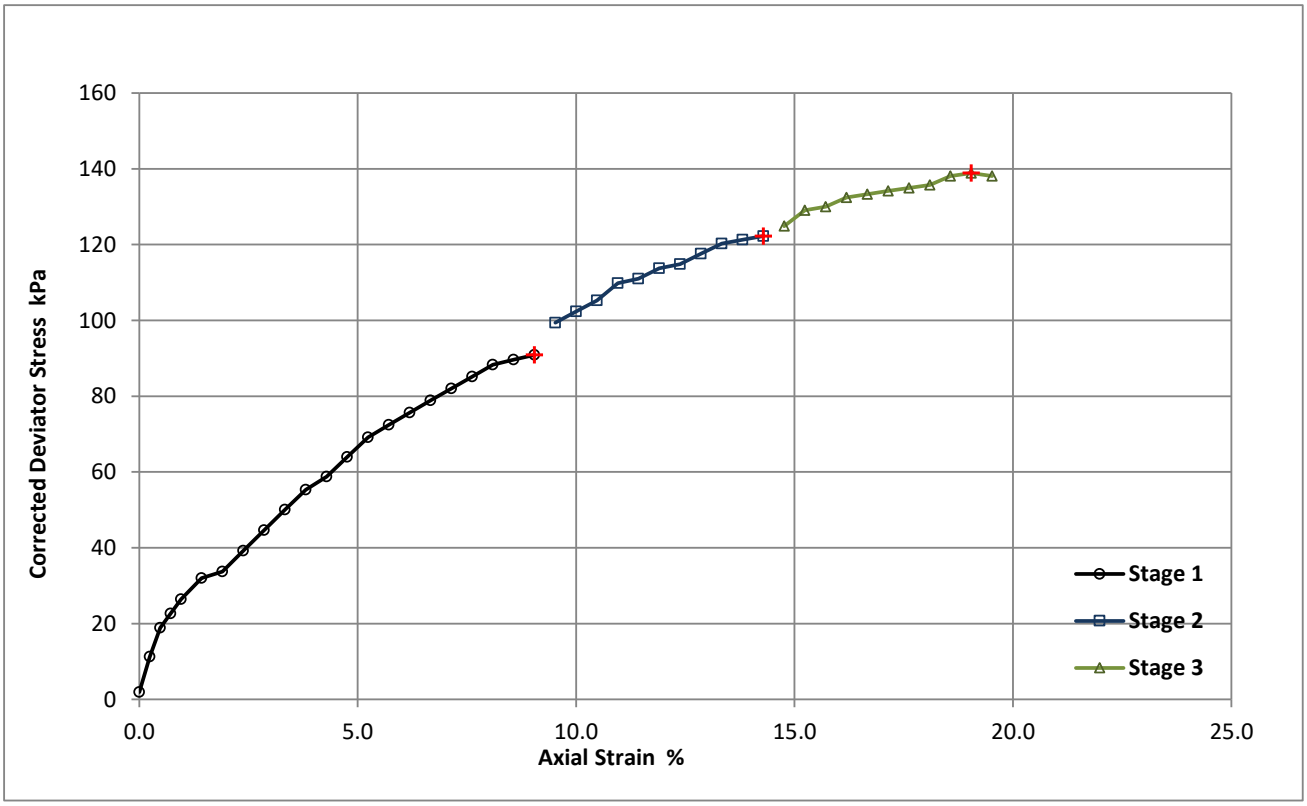
Moisture Content (%)	9.6		
Bulk Density (Mg/m^3)	2.26		
Dry Density (Mg/m^3)	2.06		
Specimen Length (mm)	210		
Specimen Diamteter (mm)	105		
Cell Pressures (kPa)	25	100	150
Deviator Stress (kPa)	183	208	218
Undrained Shear Strength (kPa)	92	104	109
Failure Strain (%)	13	16	18
Mode Of Failure	Plastic		
Membrane Used/Thickness	Rubber/0.3mm		
Rate of Strain (%/min)	3.00		

Specimen Post Test **Sample Split**

Checked	10/12/2019	Emma Sharp	
Approved	11/12/2019	Paul Evans	

UKAS TESTING 2788

GSTL	Multi Stage Unconsolidated-Undrained Triaxial Test BS 1377 : 1990 Part 7 : 9	Contract Number	46614
		Borehole/Pit No.	RCE-BH06
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine to coarse gravelly sandy silty CLAY.	Depth Top	1.20
		Depth Base	1.65
Date Tested	27/11/2019	Sample Type	UT



Moisture Content (%)	11		
Bulk Density (Mg/m^3)	2.17		
Dry Density (Mg/m^3)	1.95		
Specimen Length (mm)	210		
Specimen Diamteter (mm)	105		
Cell Pressures (kPa)	25	75	150
Deviator Stress (kPa)	91	122	139
Undrained Shear Strength (kPa)	45	61	69
Failure Strain (%)	9.0	14	19
Mode Of Failure	Plastic		
Membrane Used/Thickness	Rubber/0.3mm		
Rate of Strain (%/min)	3.00		

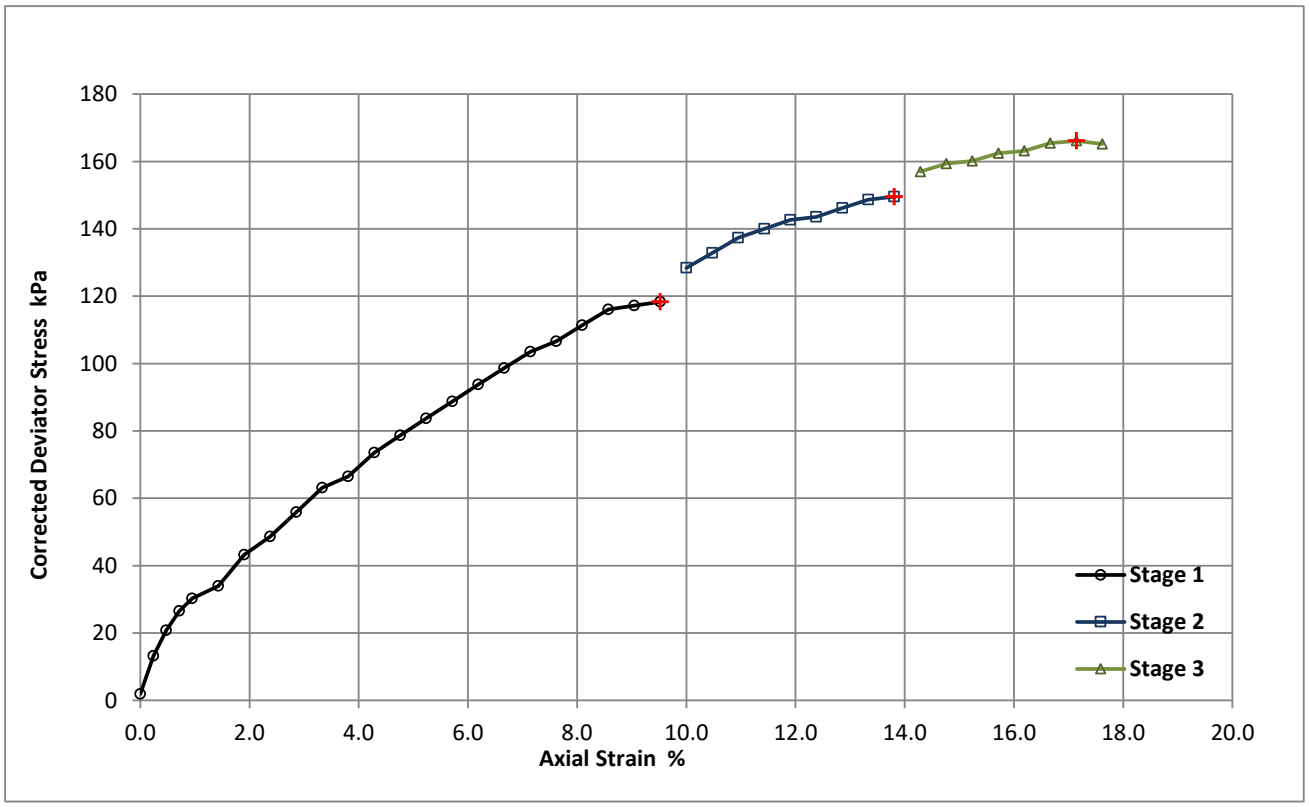
Specimen Post Test

Sample Split

Checked	10/12/2019	Emma Sharp	
Approved	11/12/2019	Paul Evans	

UKAS TESTING
2788

GSTL	Multi Stage Unconsolidated-Undrained Triaxial Test BS 1377 : 1990 Part 7 : 9	Contract Number	46614
		Borehole/Pit No.	RCE-BH07
Site Name	A40 RCE	Sample No.	12
Soil Description	Brown fine to coarse gravelly sandy silty CLAY.	Depth Top	3.00
		Depth Base	3.45
Date Tested	27/11/2019	Sample Type	UT



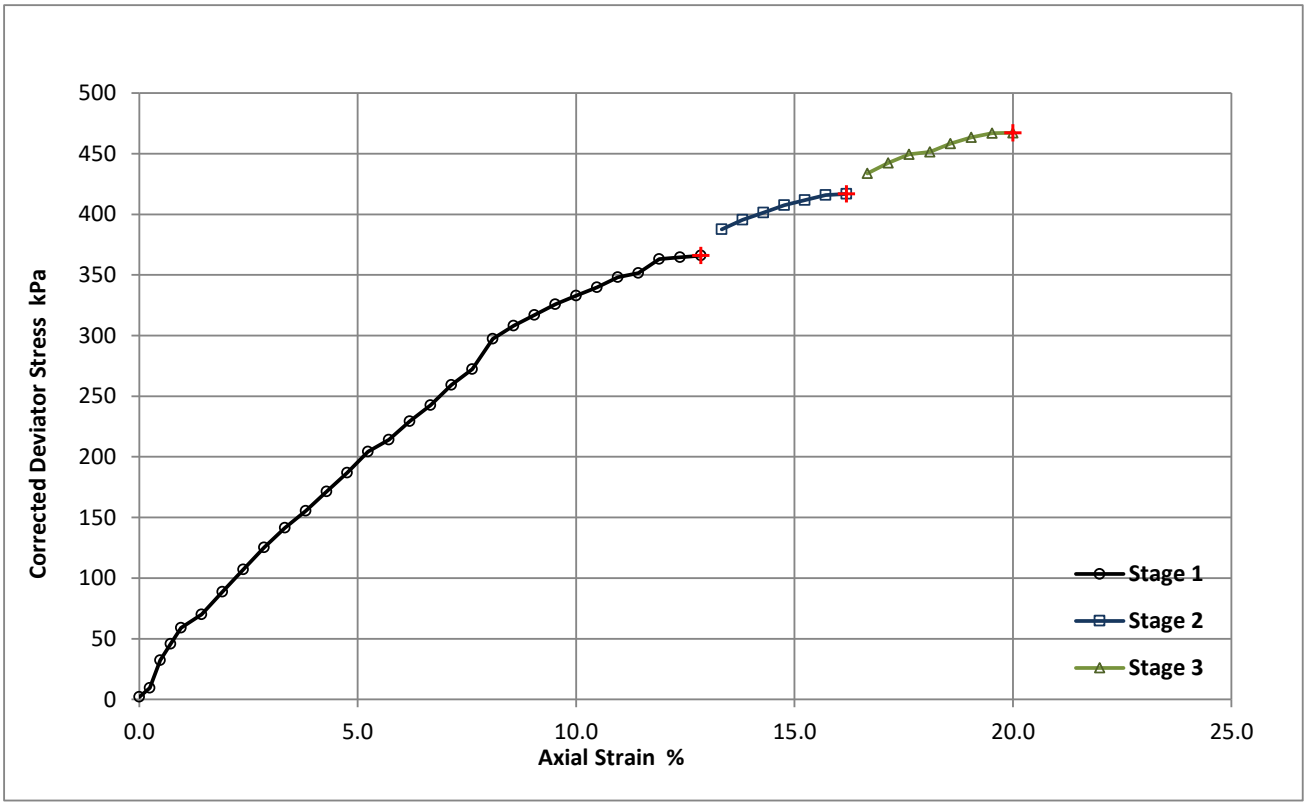
Moisture Content (%)	11		
Bulk Density (Mg/m^3)	2.26		
Dry Density (Mg/m^3)	2.03		
Specimen Length (mm)	210		
Specimen Diamteter (mm)	105		
Cell Pressures (kPa)	50	125	200
Deviator Stress (kPa)	118	150	166
Undrained Shear Strength (kPa)	59	75	83
Failure Strain (%)	9.5	14	17
Mode Of Failure	Plastic		
Membrane Used/Thickness	Rubber/0.3mm		
Rate of Strain (%/min)	3.00		

Specimen Post Test **Sample Split**

Checked	10/12/2019	Emma Sharp	
Approved	11/12/2019	Paul Evans	

UKAS TESTING 2788

GSTL	Multi Stage Unconsolidated-Undrained Triaxial Test BS 1377 : 1990 Part 7 : 9	Contract Number	46614
		Borehole/Pit No.	RCE-BH08
Site Name	A40 RCE	Sample No.	4
Soil Description	Brown fine to coarse gravelly sandy silty CLAY.	Depth Top	1.20
		Depth Base	
Date Tested	27/11/2019	Sample Type	UT



Moisture Content (%)	9.1		
Bulk Density (Mg/m^3)	2.15		
Dry Density (Mg/m^3)	1.97		
Specimen Length (mm)	210		
Specimen Diamteter (mm)	105		
Cell Pressures (kPa)	20	75	150
Deviator Stress (kPa)	366	417	467
Undrained Shear Strength (kPa)	183	208	234
Failure Strain (%)	13	16	20
Mode Of Failure	Plastic		
Membrane Used/Thickness	Rubber/0.3mm		
Rate of Strain (%/min)	3.00		

Specimen Post Test **Sample Split**

Checked	10/12/2019	Emma Sharp	
Approved	11/12/2019	Paul Evans	

UKAS TESTING 2788

Laboratory Report

2788

GEO Site & Testing Services Ltd

Contract Number: 46848

Client Ref: **Q0083**
Client PO:

Report Date: **17-12-2019**

Client **Quantum Geotechnic Ltd**
Ty Berwig
Bynea
Llanelli.
Carmarthenshire.
SA14 9ST

Contract Title: **A40 RCE**
For the attention of: **Hugh Woodroffe**

Date Received: **29-11-2019**
Date Completed: **17-12-2019**

Test Description	Qty
Moisture Content BS 1377:1990 - Part 2 : 3.2 - * UKAS	28
4 Point Liquid & Plastic Limit BS 1377:1990 - Part 2 : 4.3 & 5.3 - * UKAS	28
PSD Wet Sieve method BS 1377:1990 - Part 2 : 9.2 - * UKAS	27
BRE Suite B Greenfield Site (pyrite present) **includes pH, water & acid soluble sulphate and total sulphur** BRE - BR279 - @ Non Accredited Test	19
Dry Den/MC (2.5kg Rammer Method 1 Litre Mould) BS 1377:1990 - Part 4 : 3.3 - * UKAS	1
MCV/Moisture Content Relation BS 1377:1990 - Part 4 : 5.5 - * UKAS	1

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
 # - denotes test carried out by approved contractor
@ - denotes non accredited tests

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved Signatories:
Emma Sharp (Office Manager) - Paul Evans (Quality/Technical Manager) - Richard John (Advanced Testing Manager)
Sean Penn (Administrative/Accounts Assistant) - Shaun Jones (Laboratory manager) - Wayne Honey (Administrative/Quality Assistant)

GEO Site & Testing Services Ltd
Unit 3-4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

Laboratory Report

2788

GEO Site & Testing Services Ltd

Contract Number: 46848

Test Description	Qty
Immediate Shear Strength - set of 3 60 x 60 mm Shear Box Specimens by Direct Shearing (note suitable for free draining material only) BS 1377:1990 - Part 7 : 4 - * UKAS	3
Determination of Point Load Value Axial or Diametrical including WC ***Please note GSTL is not accredited for the water content of rock*** ISRM Suggested Method for Point Load Strength - * UKAS	34
Disposal of samples for job	1

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
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Approved Signatories:
Emma Sharp (Office Manager) - Paul Evans (Quality/Technical Manager) - Richard John (Advanced Testing Manager)
Sean Penn (Administrative/Accounts Assistant) - Shaun Jones (Laboratory manager) - Wayne Honey (Administrative/Quality Assistant)

GEO Site & Testing Services Ltd
Unit 3-4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46848	
Site Name	A40 RCE	
Date Tested	09/12/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCEBH01			3.00	-		Brown GRAVEL with cobbles
RCEBH02			4.00	-		Brown silty sandy GRAVEL.
RCEBH03			4.75	-		Brown slightly sandy GRAVEL.
RCEBH03			6.25	-		Brown slightly sandy GRAVEL.
RCEBH03			8.60	-		Brown slightly sandy GRAVEL.
RCEBH05			6.50	-		Brown gravelly sandy silty CLAY.
RCEBH06			9.00	-		Brown silty sandy GRAVEL.With cobbles
RCEBH07			10.50	-		Brown silty sandy GRAVEL.
RCEBH08			5.00	-		Brown silty sandy GRAVEL.
RCEBH08			9.00	-		Brown silty sandy GRAVEL.
RCEBH09			3.00	-		Brown silty sandy GRAVEL.
RCEBH10			1.25	-		Brown silty sandy GRAVEL. With cobbles
RCEBH11			1.00	-		Brown silty sandy GRAVEL.
RCEBH11			4.00	-		Brown silty sandy GRAVEL. With cobbles
RCEBH11			6.00	-		Brown silty sandy GRAVEL. With cobbles
RCEBH12			3.50	-		Brown silty sandy GRAVEL.
RCEBH12			8.00	-		Brown silty sandy GRAVEL.
RCEBH12			4.75	-		Brown silty sandy GRAVEL. With cobbles
RCEBH13			8.50	-		Brown silty sandy GRAVEL.
RCEBH13			10.00	-		Brown silty sandy GRAVEL.
RCEBH14			2.00	-		Brown silty sandy GRAVEL. With cobbles
RCEBH14			4.00	-		Brown silty sandy GRAVEL. With cobbles
RCEBH15			8.00	-		Brown silty sandy GRAVEL.
				-		

Operators	Checked	17/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	17/12/2019	Paul Evans (Quality/Technical Manager)

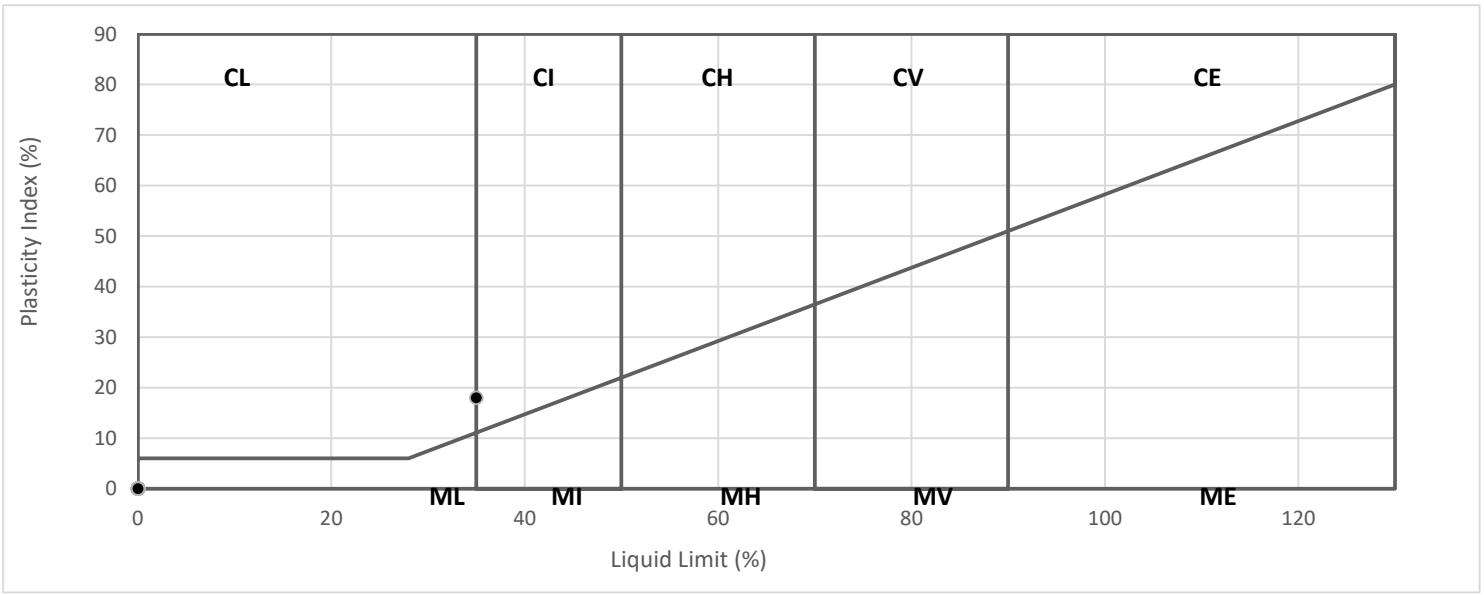
UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	**46848**	
Project Location	**A40 RCE**	
Date Tested	**09/12/2019**	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCEBH01			3.00	-		1.7		NP		2	
RCEBH02			4.00	-		9.5		NP		13	
RCEBH03			4.75	-		3.0		NP		1	
RCEBH03			6.25	-		2.5		NP		1	
RCEBH03			8.60	-		1.8		NP		1	
RCEBH05			6.50	-		20	35	17	18	49	CL/I Low/Inter. Plasticity
RCEBH06			9.00	-		1.6		NP		4	
RCEBH07			10.50	-		7.9		NP		5	
RCEBH08			5.00	-		4.9		NP		6	
RCEBH08			9.00	-		5.3		NP		3	
RCEBH09			3.00	-		6.9		NP		8	
RCEBH10			1.25	-		3.6		NP		7	
RCEBH11			1.00	-		5.9		NP		3	
RCEBH11			4.00	-		3.1		NP		2	
RCEBH11			6.00	-		1.6		NP		1	
RCEBH12			3.50	-		3.1		NP		9	
RCEBH12			8.00	-		6.9		NP		3	
RCEBH12			4.75	-		4.9		NP		1	
RCEBH13			8.50	-		2.9		NP		2	
RCEBH13			10.00	-		1.8		NP		1	
RCEBH14			2.00	-		6.2		NP		1	
RCEBH14			4.00	-		4.5		NP		1	
RCEBH15			8.00	-		6.7		NP		3	
				-							

Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	17/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	17/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46848	
Site Name	A40 RCE	
Date Tested	09/12/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCEBH16			1.25	-		Brown silty sandy GRAVEL.
RCEBH16			3.00	-		Brown silty sandy GRAVEL. With cobbles
RCEBH16			5.75	-		Brown silty sandy GRAVEL.
RCEBH16			8.25	-		Brown silty sandy GRAVEL. With cobbles
RCE-TP19	6	LB	2.00	-	2.50	Brown sandy gravel.
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		

Operators	Checked	17/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	17/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	**46848**	
Project Location	**A40 RCE**	
Date Tested	**09/12/2019**	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCEBH16			1.25	-		6.2		NP		3	
RCEBH16			3.00	-		4.7		NP		3	
RCEBH16			5.75	-		4.1		NP		1	
RCEBH16			8.25	-		3.1		NP		4	
RCE-TP19	6	LB	2.00	-	2.50	4.5		NP		2	
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							
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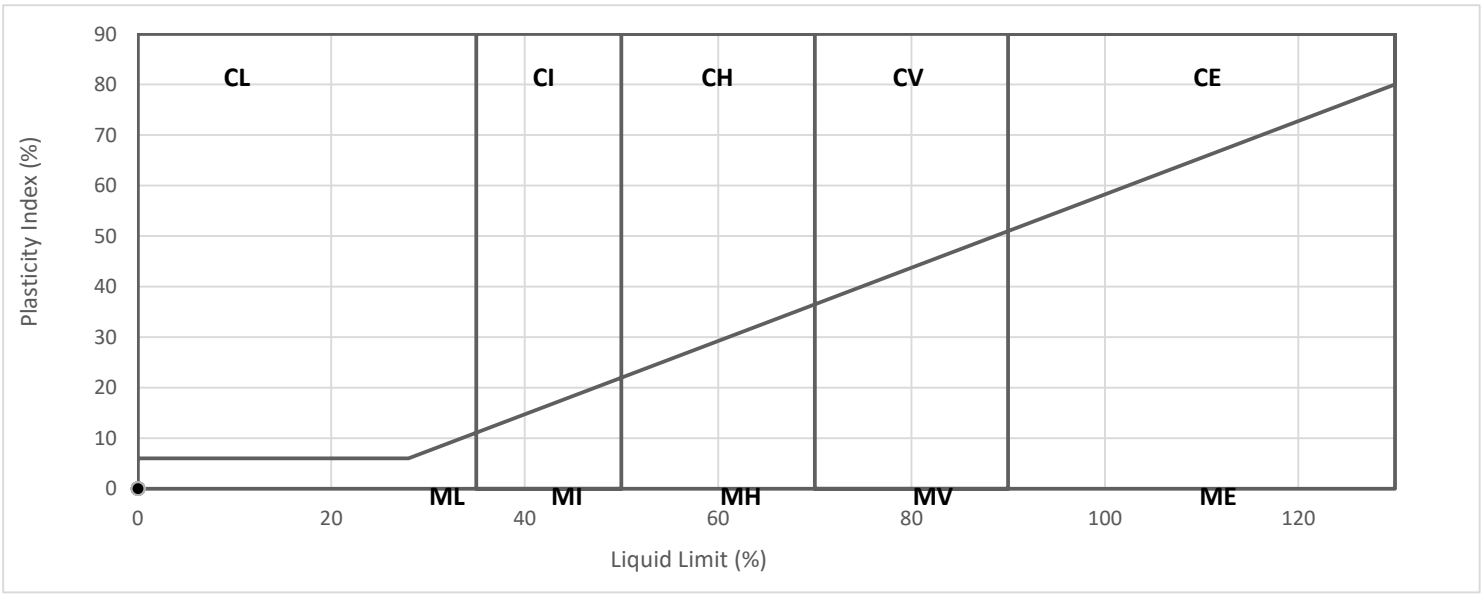
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							

Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

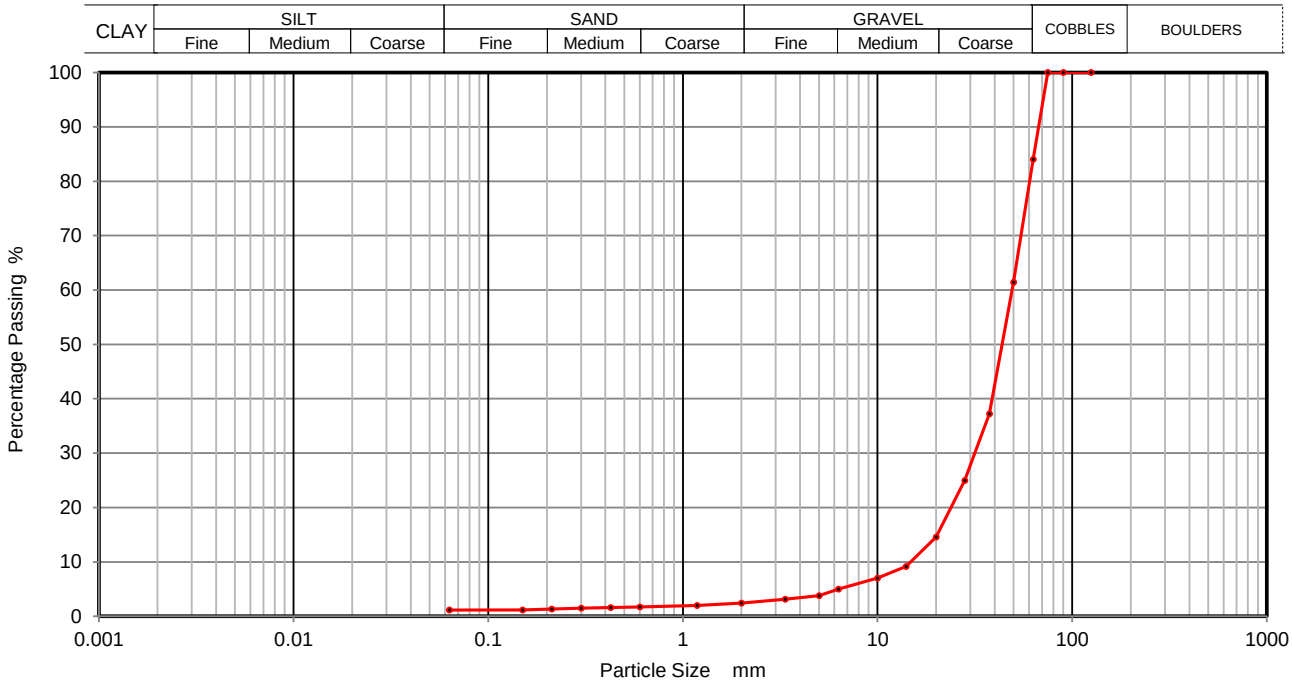
PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	17/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	17/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH01
Site Name	A40 RCE	Sample No.	
Soil Description	Brown GRAVEL with cobbles	Depth Top	3.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	84		
50	61		
37.5	37		
28	25		
20	15		
14	9		
10	7		
6.3	5		
5	4		
3.35	3		
2	2		
1.18	2		
0.6	2		
0.425	2		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	16
Gravel	82
Sand	1
Silt and Clay	1

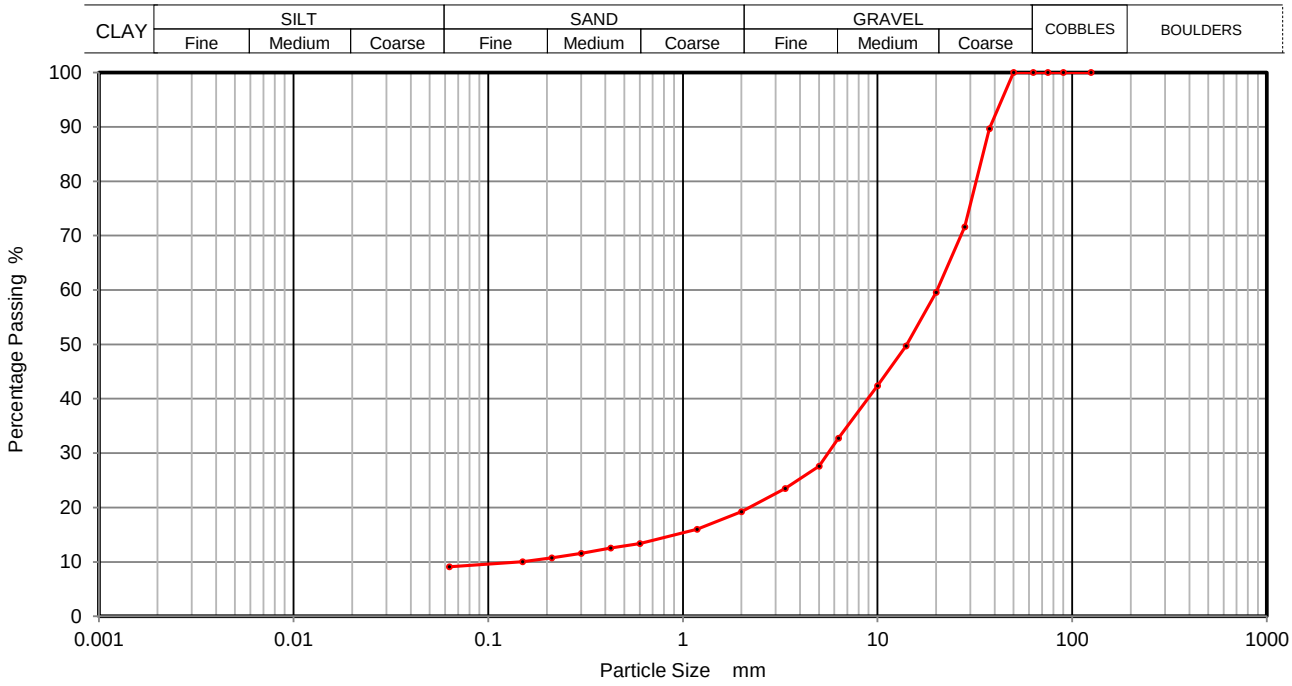
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH02
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	4.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	90		
28	72		
20	60		
14	50		
10	42		
6.3	33		
5	28		
3.35	23		
2	19		
1.18	16		
0.6	13		
0.425	13		
0.3	12		
0.212	11		
0.15	10		
0.063	9		

Sample Proportions	% dry mass
Cobbles	0
Gravel	81
Sand	10
Silt and Clay	9

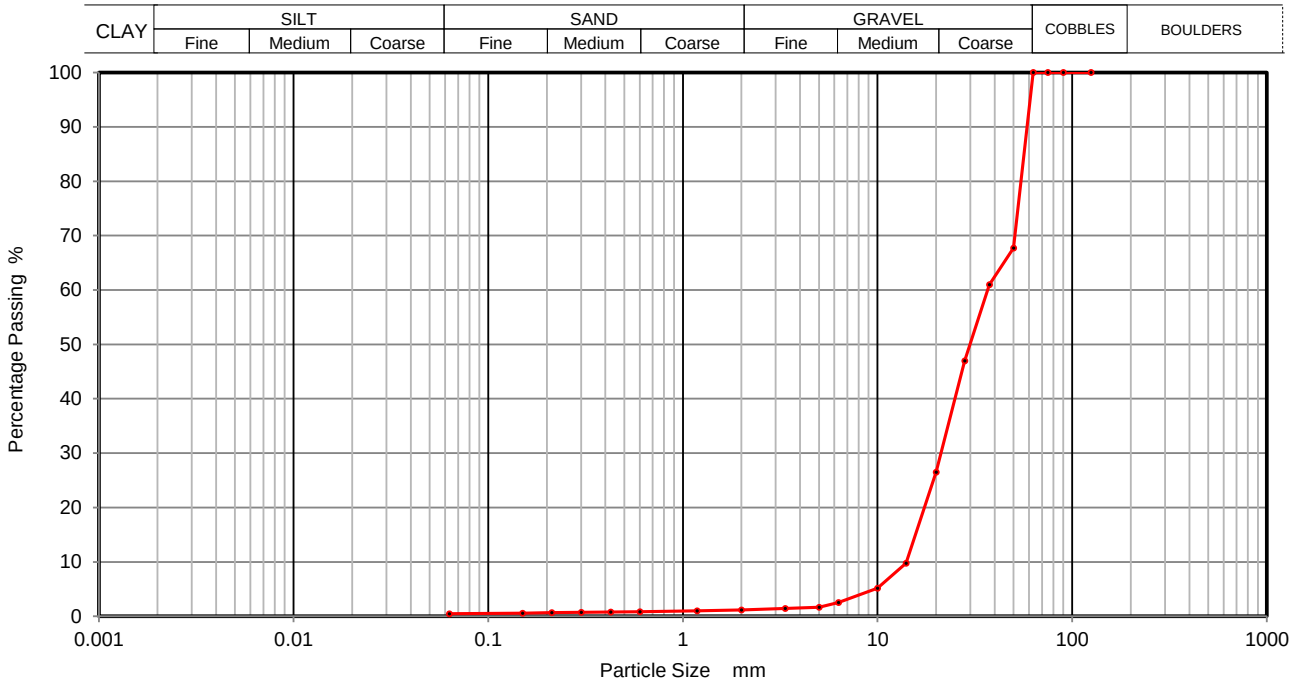
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH03
Site Name	A40 RCE	Sample No.	
Soil Description	Brown slightly sandy GRAVEL.	Depth Top	4.75
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	68		
37.5	61		
28	47		
20	26		
14	10		
10	5		
6.3	3		
5	2		
3.35	1		
2	1		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	1		
0.063	0		

Sample Proportions	% dry mass
Cobbles	0
Gravel	99
Sand	1
Silt and Clay	0

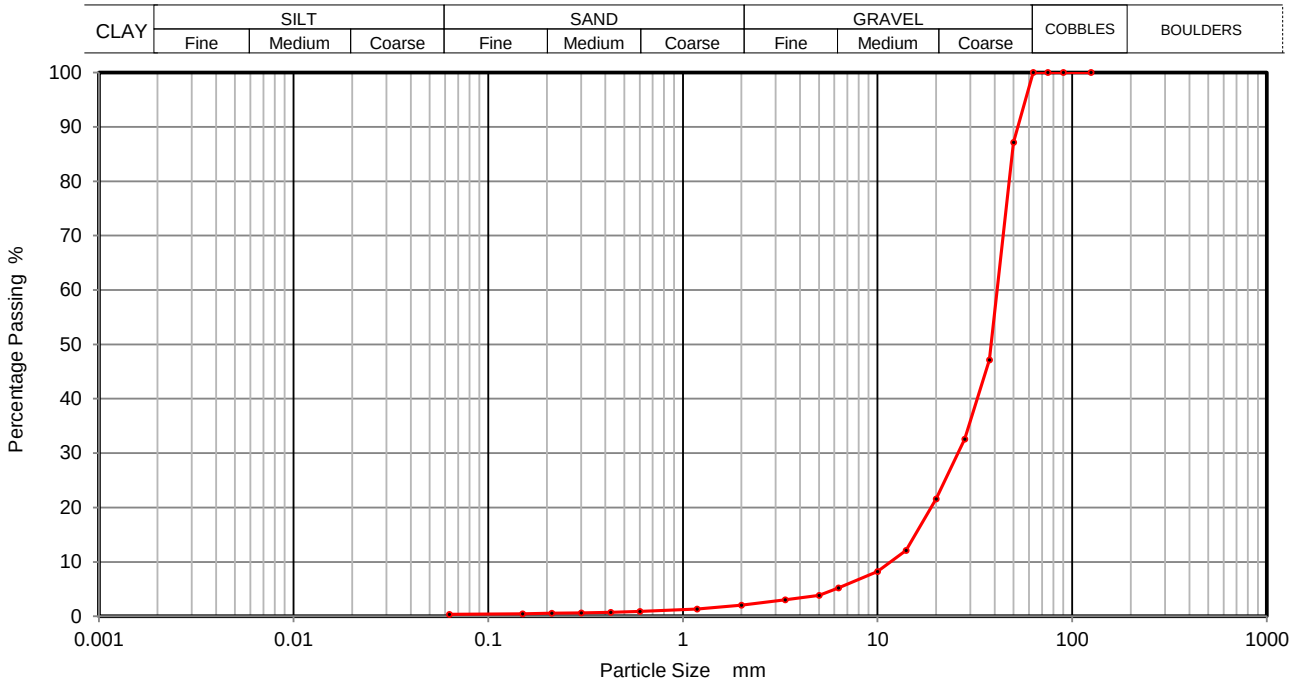
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH03
Site Name	A40 RCE	Sample No.	
Soil Description	Brown slightly sandy GRAVEL.	Depth Top	6.25
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	87		
37.5	47		
28	33		
20	22		
14	12		
10	8		
6.3	5		
5	4		
3.35	3		
2	2		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	0		
0.063	0		

Sample Proportions	% dry mass
Cobbles	0
Gravel	98
Sand	2
Silt and Clay	0

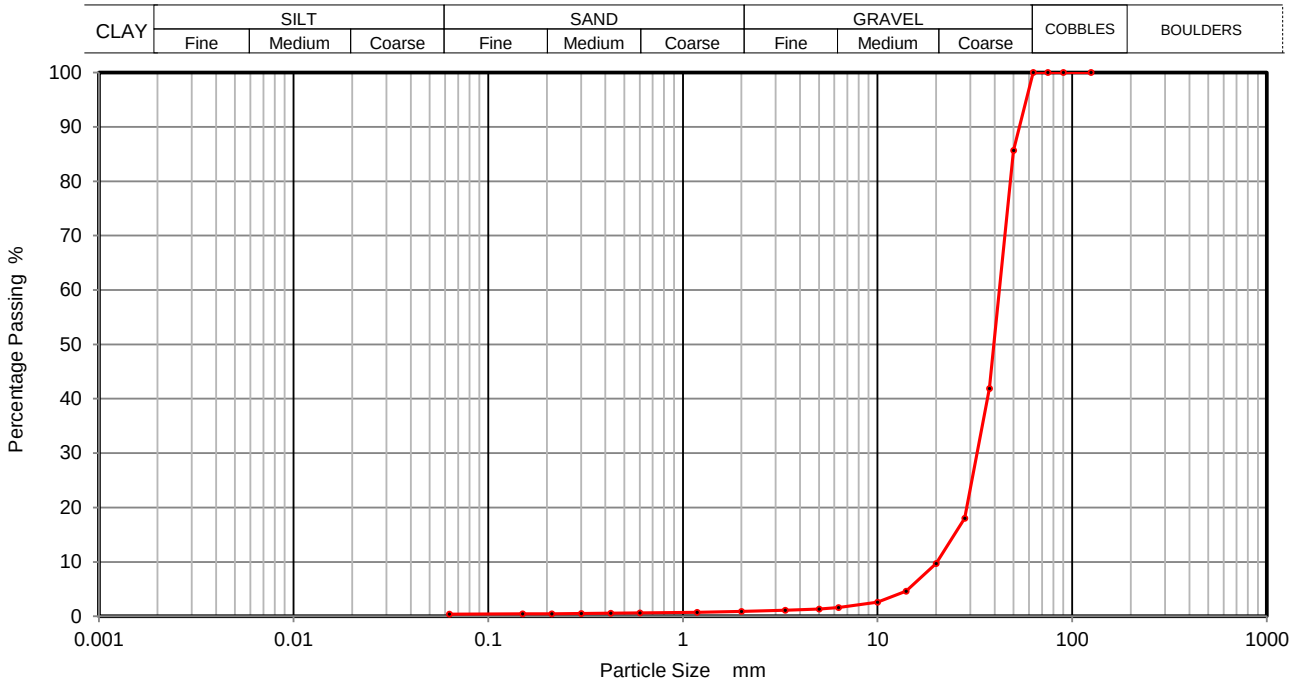
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH03
Site Name	A40 RCE	Sample No.	
Soil Description	Brown slightly sandy GRAVEL.	Depth Top	8.60
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	86		
37.5	42		
28	18		
20	10		
14	5		
10	3		
6.3	2		
5	1		
3.35	1		
2	1		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	0		
0.15	0		
0.063	0		

Sample Proportions	% dry mass
Cobbles	0
Gravel	99
Sand	1
Silt and Clay	0

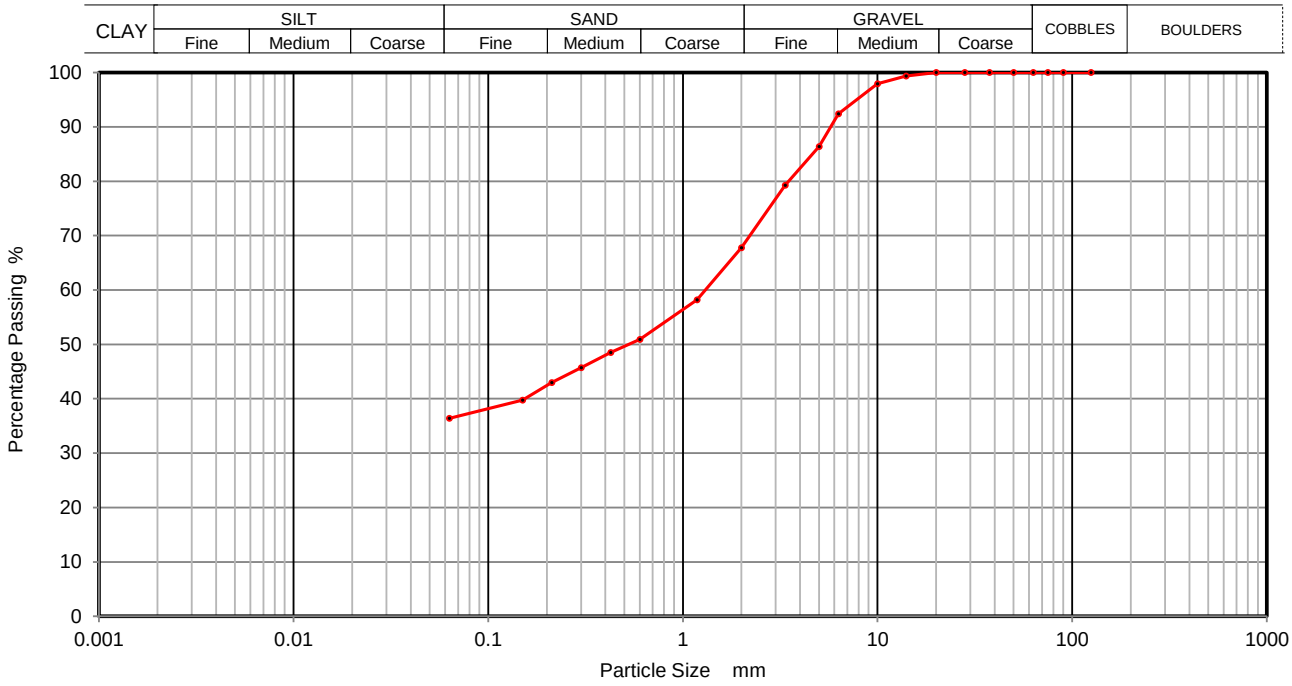
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH05
Site Name	A40 RCE	Sample No.	
Soil Description	Brown gravelly sandy silty CLAY.	Depth Top	6.50
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	99		
10	98		
6.3	92		
5	86		
3.35	79		
2	68		
1.18	58		
0.6	51		
0.425	49		
0.3	46		
0.212	43		
0.15	40		
0.063	36		

Sample Proportions	% dry mass
Cobbles	0
Gravel	32
Sand	32
Silt and Clay	36

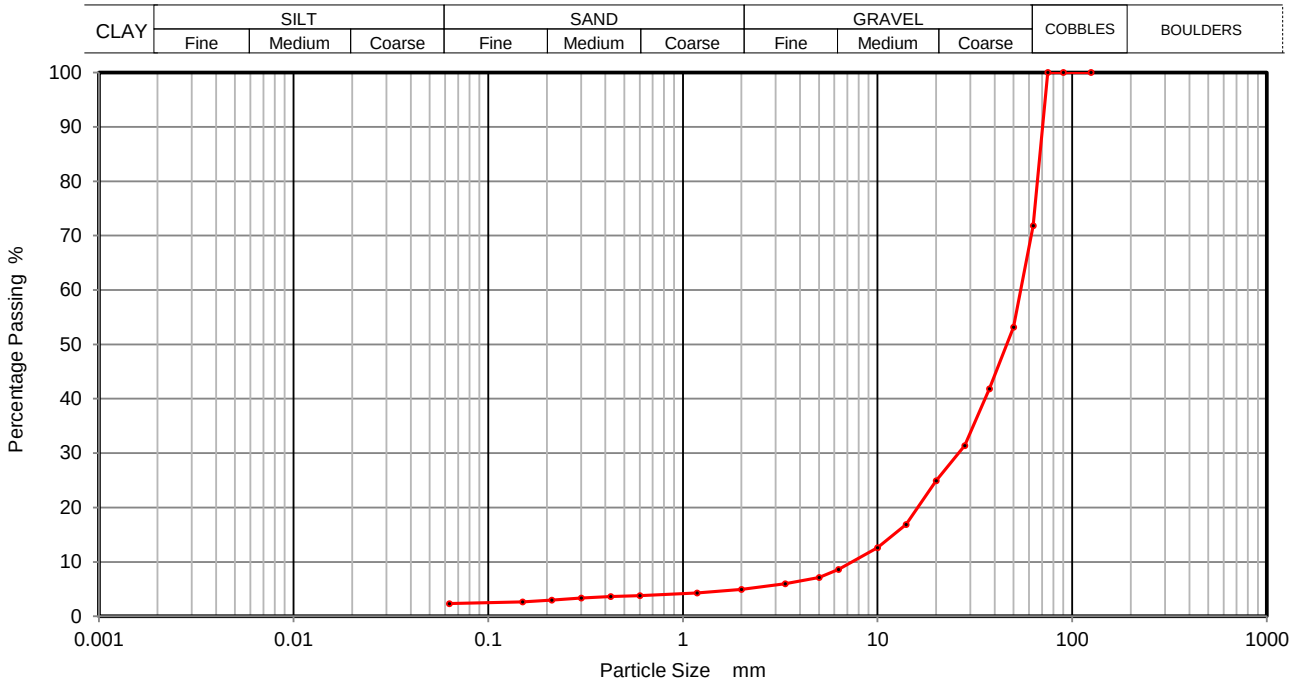
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH06
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.With cobbles	Depth Top	9.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	72		
50	53		
37.5	42		
28	31		
20	25		
14	17		
10	13		
6.3	9		
5	7		
3.35	6		
2	5		
1.18	4		
0.6	4		
0.425	4		
0.3	3		
0.212	3		
0.15	3		
0.063	2		

Sample Proportions	% dry mass
Cobbles	28
Gravel	67
Sand	3
Silt and Clay	2

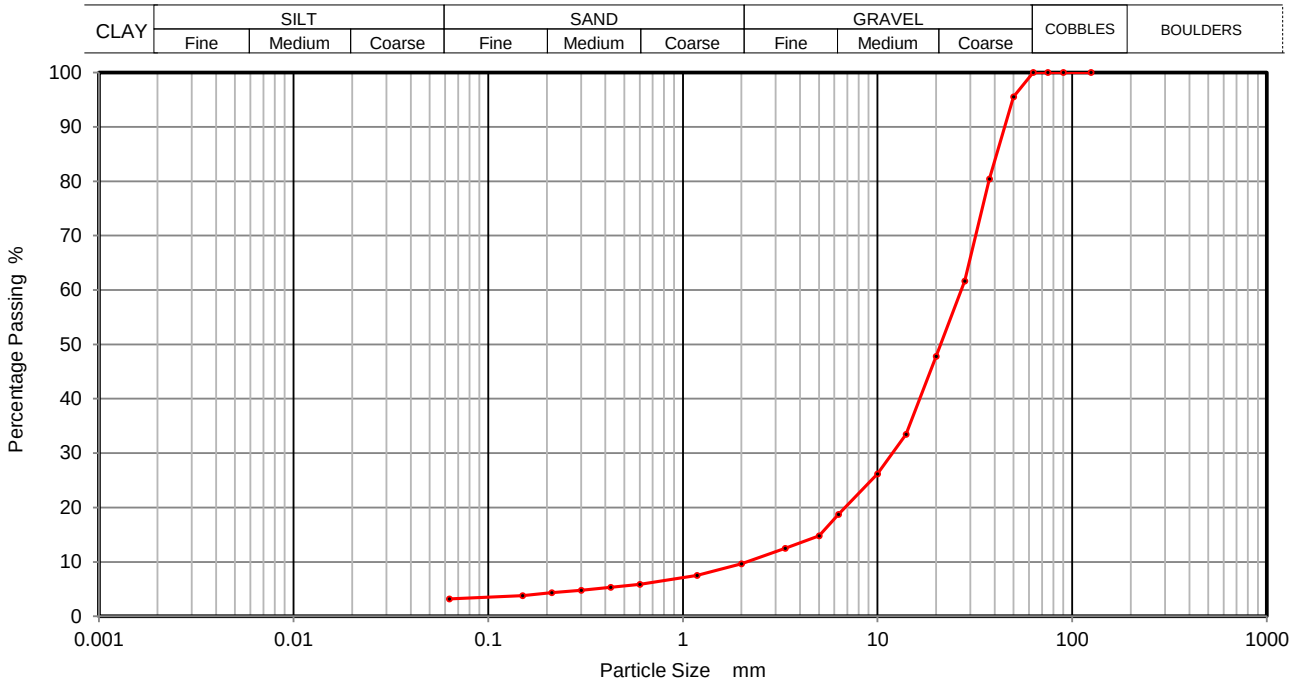
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH07
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	10.50
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	96		
37.5	80		
28	62		
20	48		
14	33		
10	26		
6.3	19		
5	15		
3.35	13		
2	10		
1.18	8		
0.6	6		
0.425	5		
0.3	5		
0.212	4		
0.15	4		
0.063	3		

Sample Proportions	% dry mass
Cobbles	0
Gravel	90
Sand	7
Silt and Clay	3

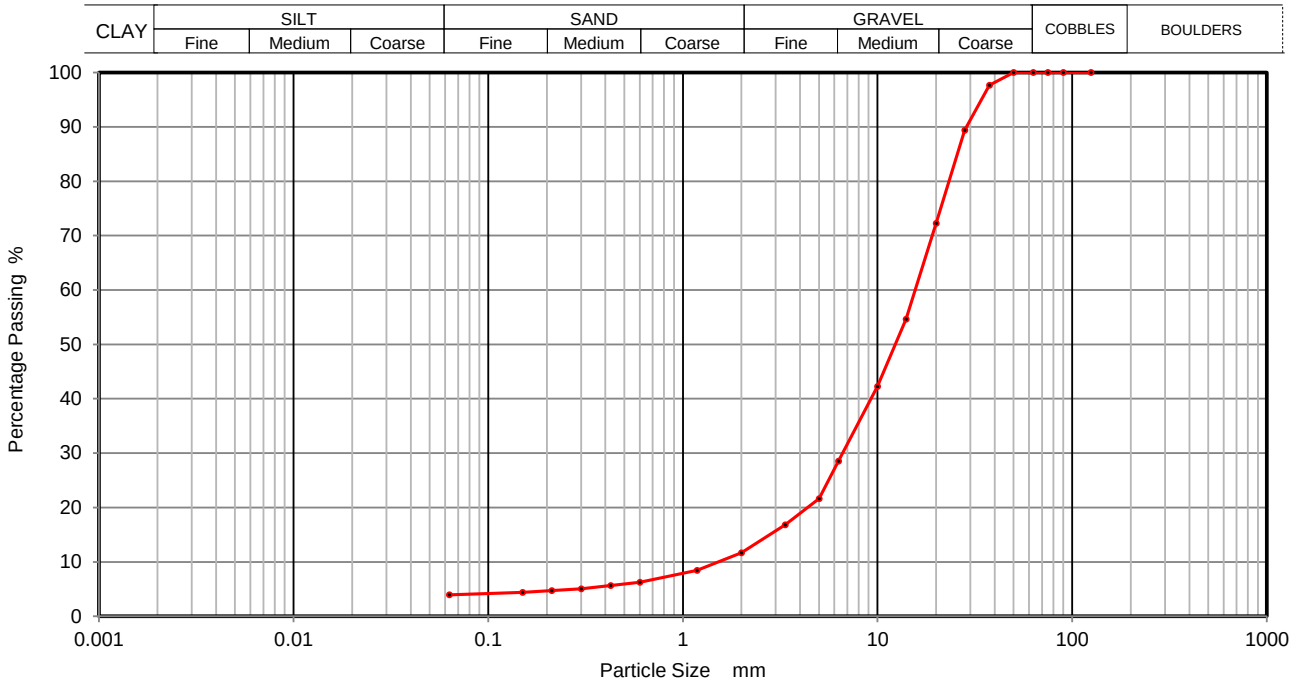
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH08
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	5.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	98		
28	89		
20	72		
14	55		
10	42		
6.3	29		
5	22		
3.35	17		
2	12		
1.18	8		
0.6	6		
0.425	6		
0.3	5		
0.212	5		
0.15	4		
0.063	4		

Sample Proportions	% dry mass
Cobbles	0
Gravel	88
Sand	8
Silt and Clay	4

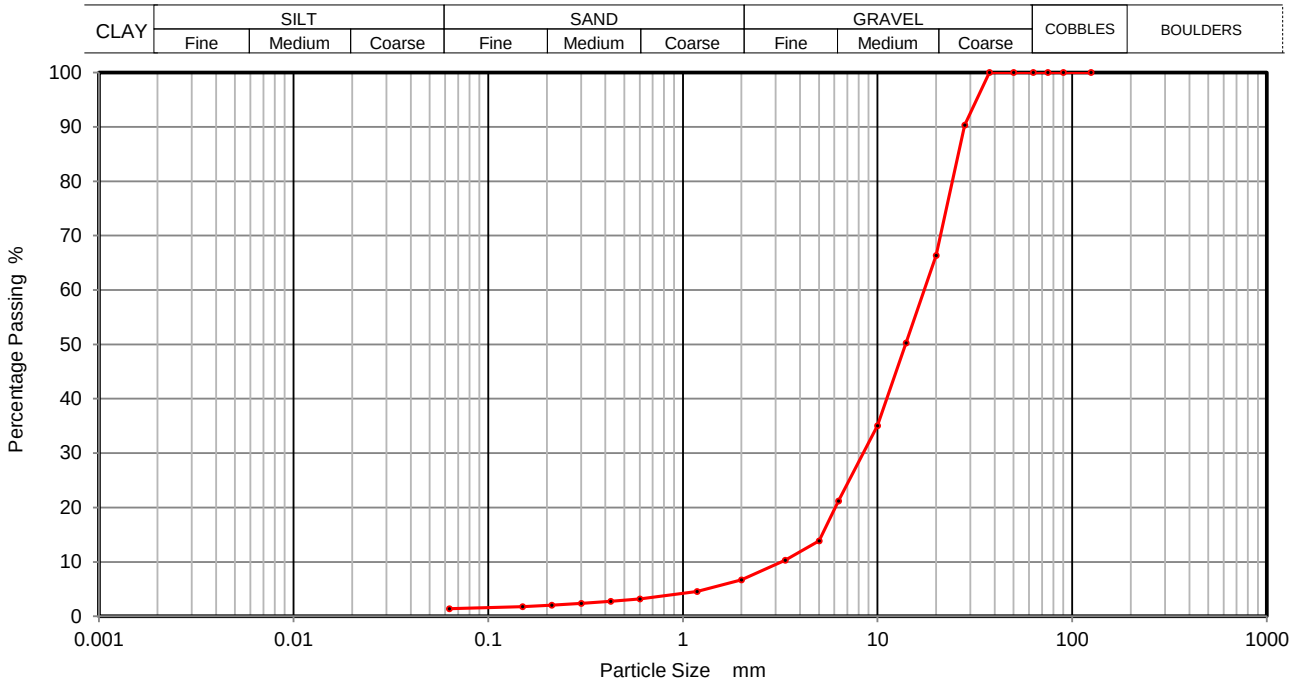
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH08
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	9.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	90		
20	66		
14	50		
10	35		
6.3	21		
5	14		
3.35	10		
2	7		
1.18	5		
0.6	3		
0.425	3		
0.3	2		
0.212	2		
0.15	2		
0.063	1		

Sample Proportions	% dry mass
Cobbles	0
Gravel	93
Sand	6
Silt and Clay	1

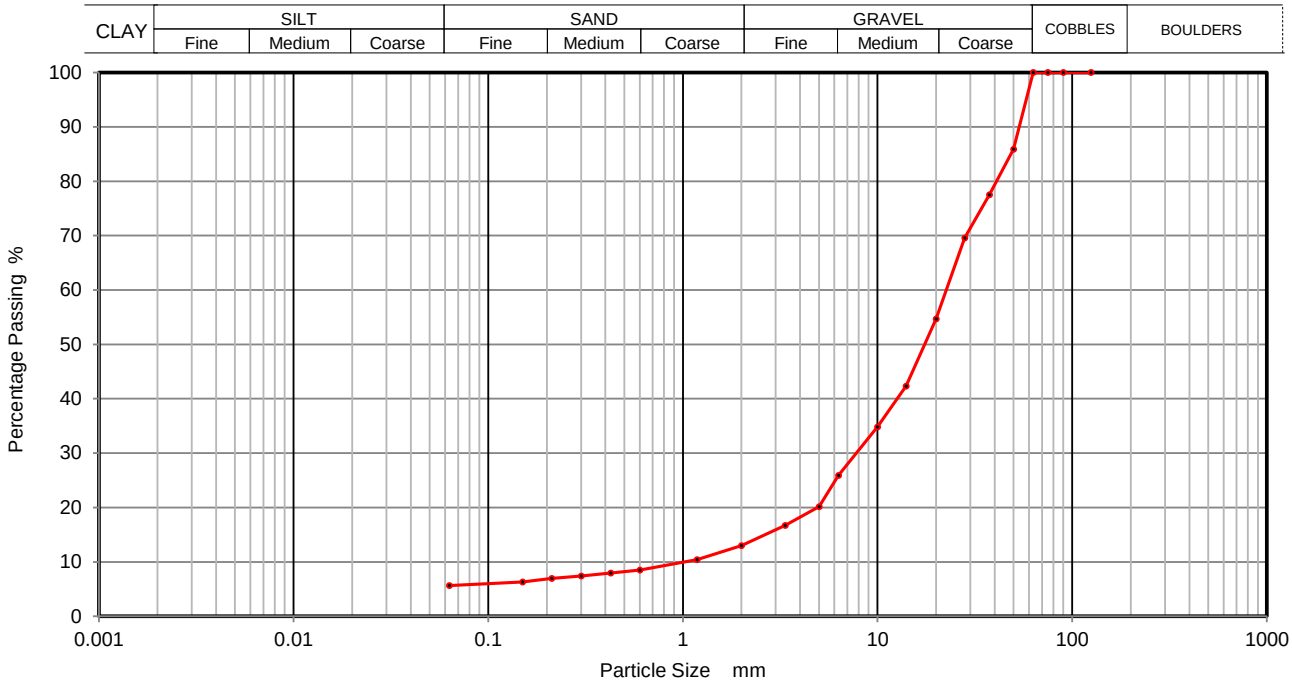
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH09
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	3.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	86		
37.5	78		
28	70		
20	55		
14	42		
10	35		
6.3	26		
5	20		
3.35	17		
2	13		
1.18	10		
0.6	9		
0.425	8		
0.3	7		
0.212	7		
0.15	6		
0.063	6		

Sample Proportions	% dry mass
Cobbles	0
Gravel	87
Sand	7
Silt and Clay	6

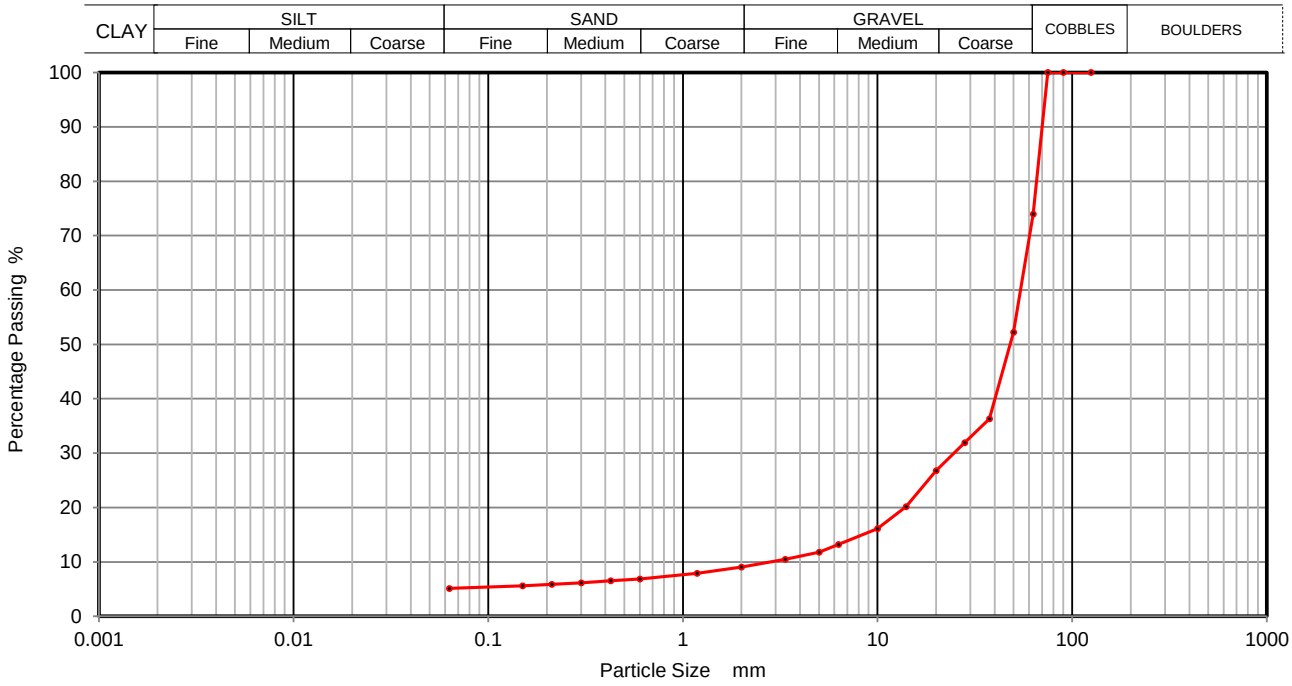
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH10
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	1.25
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	74		
50	52		
37.5	36		
28	32		
20	27		
14	20		
10	16		
6.3	13		
5	12		
3.35	10		
2	9		
1.18	8		
0.6	7		
0.425	7		
0.3	6		
0.212	6		
0.15	6		
0.063	5		

Sample Proportions	% dry mass
Cobbles	26
Gravel	65
Sand	4
Silt and Clay	5

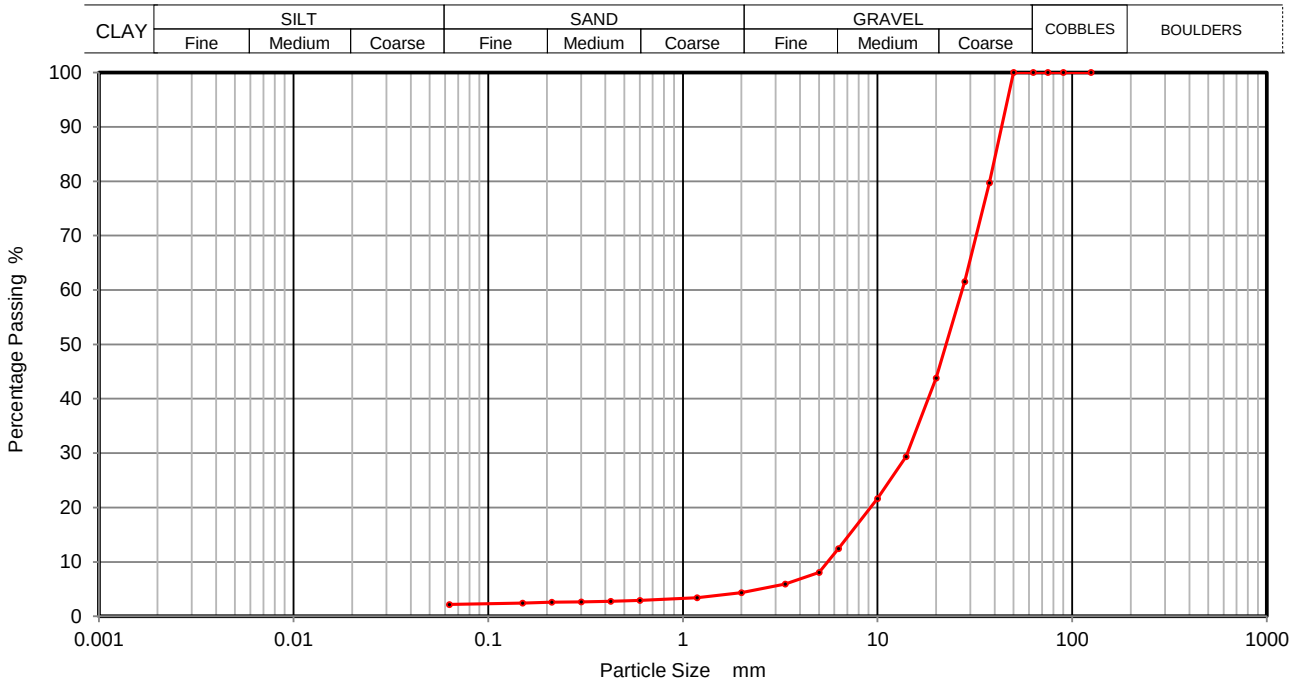
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH11
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	1.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	80		
28	62		
20	44		
14	29		
10	22		
6.3	12		
5	8		
3.35	6		
2	4		
1.18	3		
0.6	3		
0.425	3		
0.3	3		
0.212	3		
0.15	2		
0.063	2		

Sample Proportions	% dry mass
Cobbles	0
Gravel	96
Sand	2
Silt and Clay	2

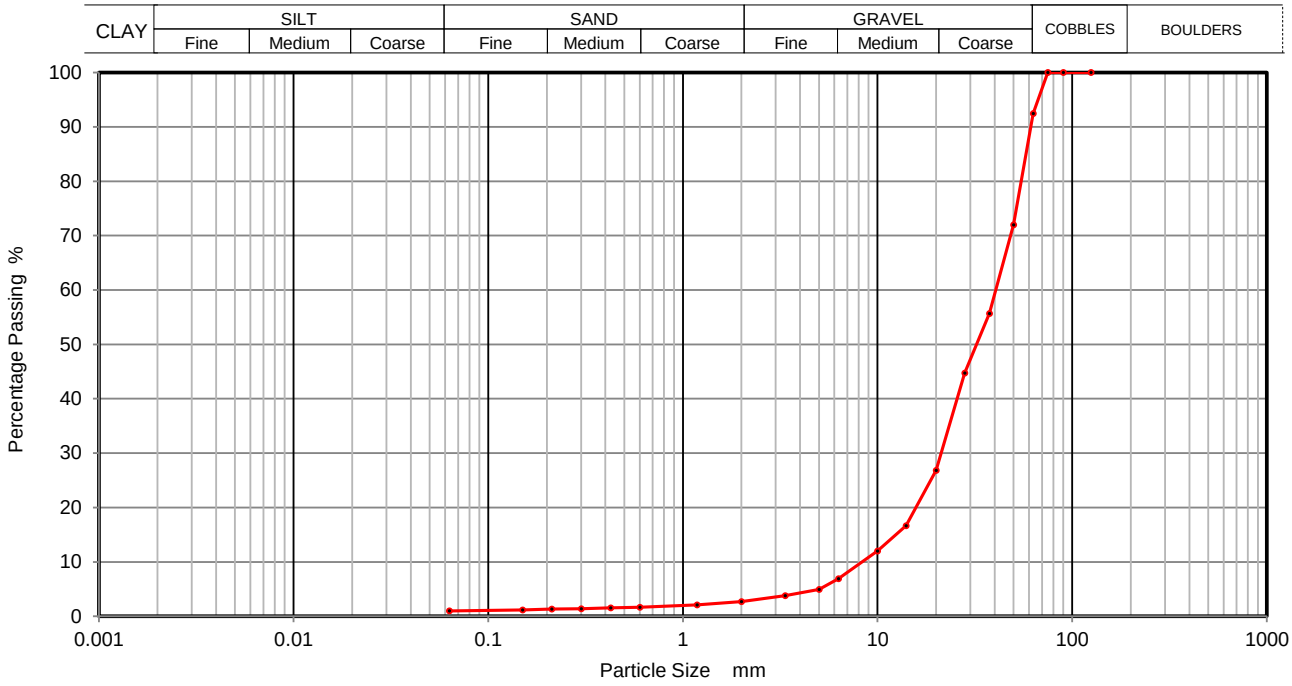
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH11
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	4.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	92		
50	72		
37.5	56		
28	45		
20	27		
14	17		
10	12		
6.3	7		
5	5		
3.35	4		
2	3		
1.18	2		
0.6	2		
0.425	2		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	8
Gravel	89
Sand	2
Silt and Clay	1

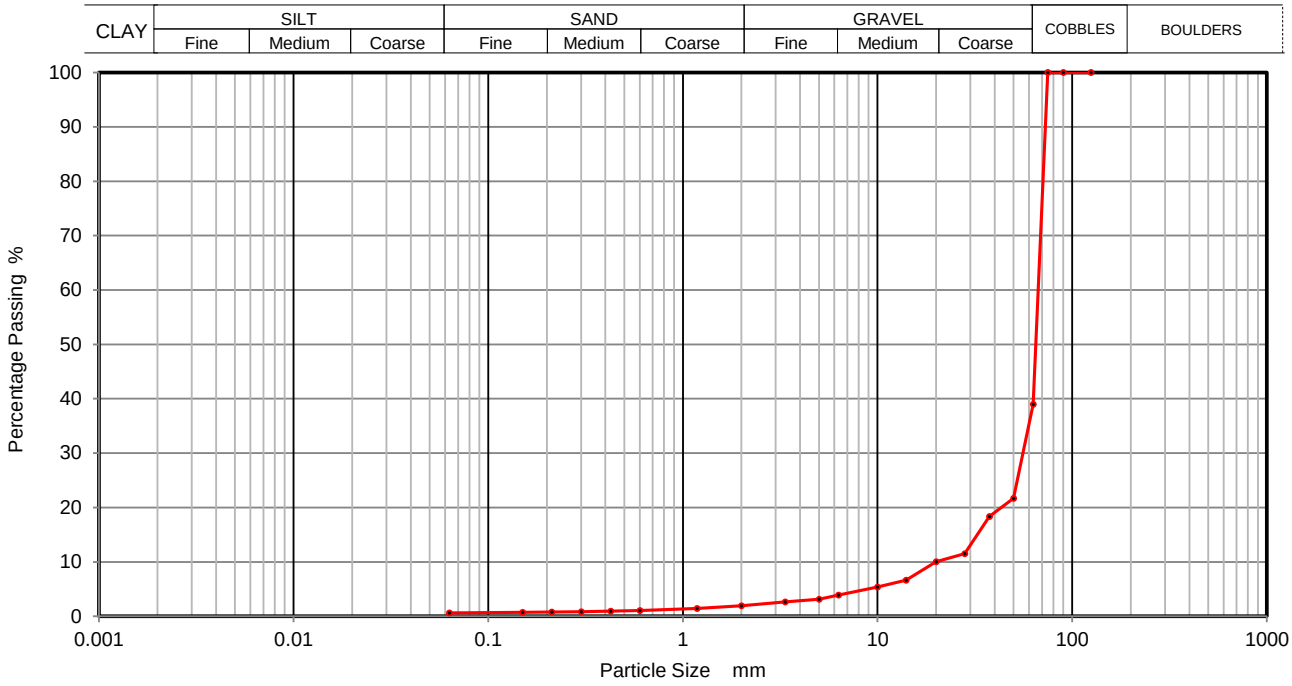
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH11
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	6.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	39		
50	22		
37.5	18		
28	11		
20	10		
14	7		
10	5		
6.3	4		
5	3		
3.35	3		
2	2		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	61
Gravel	37
Sand	1
Silt and Clay	1

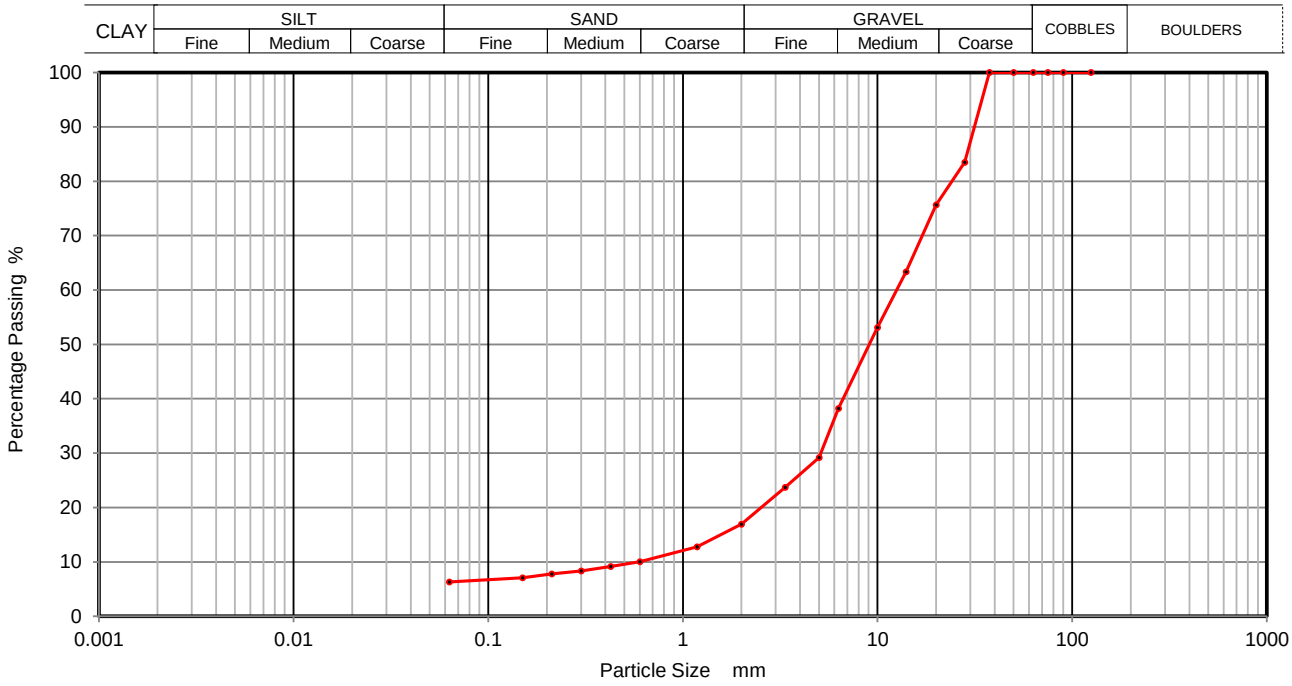
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH12
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	3.50
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	83		
20	76		
14	63		
10	53		
6.3	38		
5	29		
3.35	24		
2	17		
1.18	13		
0.6	10		
0.425	9		
0.3	8		
0.212	8		
0.15	7		
0.063	6		

Sample Proportions	% dry mass
Cobbles	0
Gravel	83
Sand	11
Silt and Clay	6

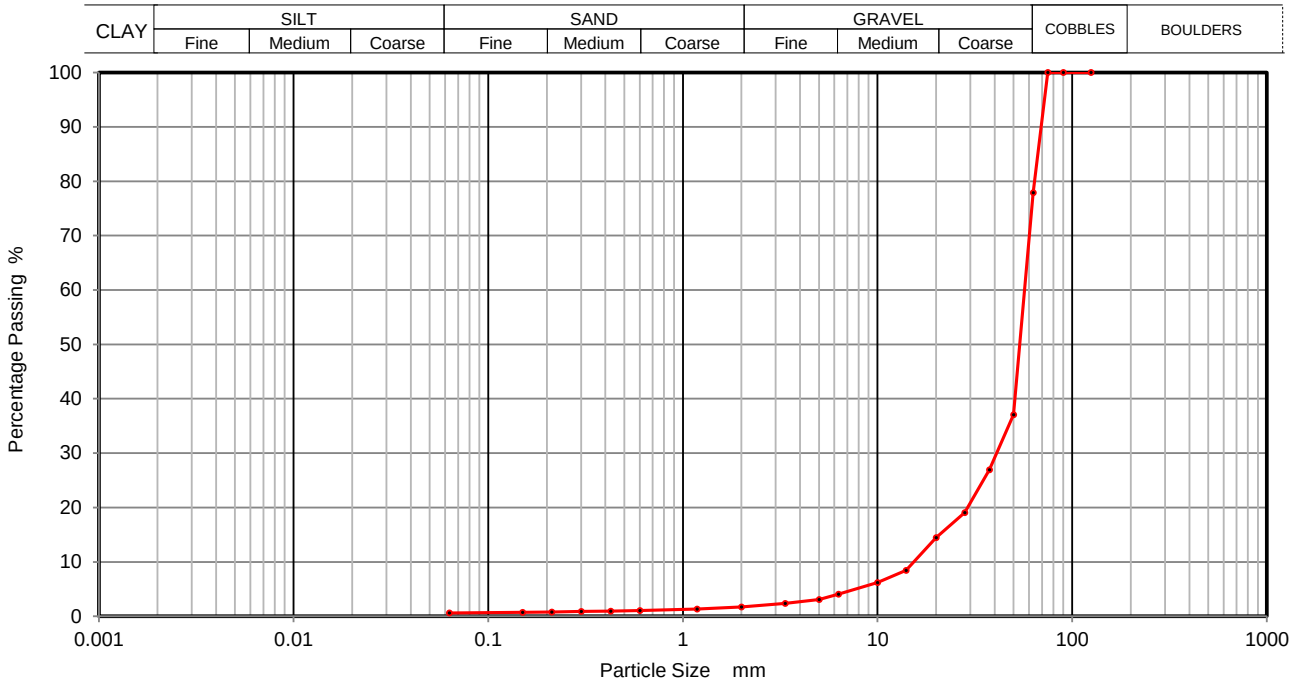
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH12
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	4.75
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	78		
50	37		
37.5	27		
28	19		
20	14		
14	8		
10	6		
6.3	4		
5	3		
3.35	2		
2	2		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	22
Gravel	76
Sand	1
Silt and Clay	1

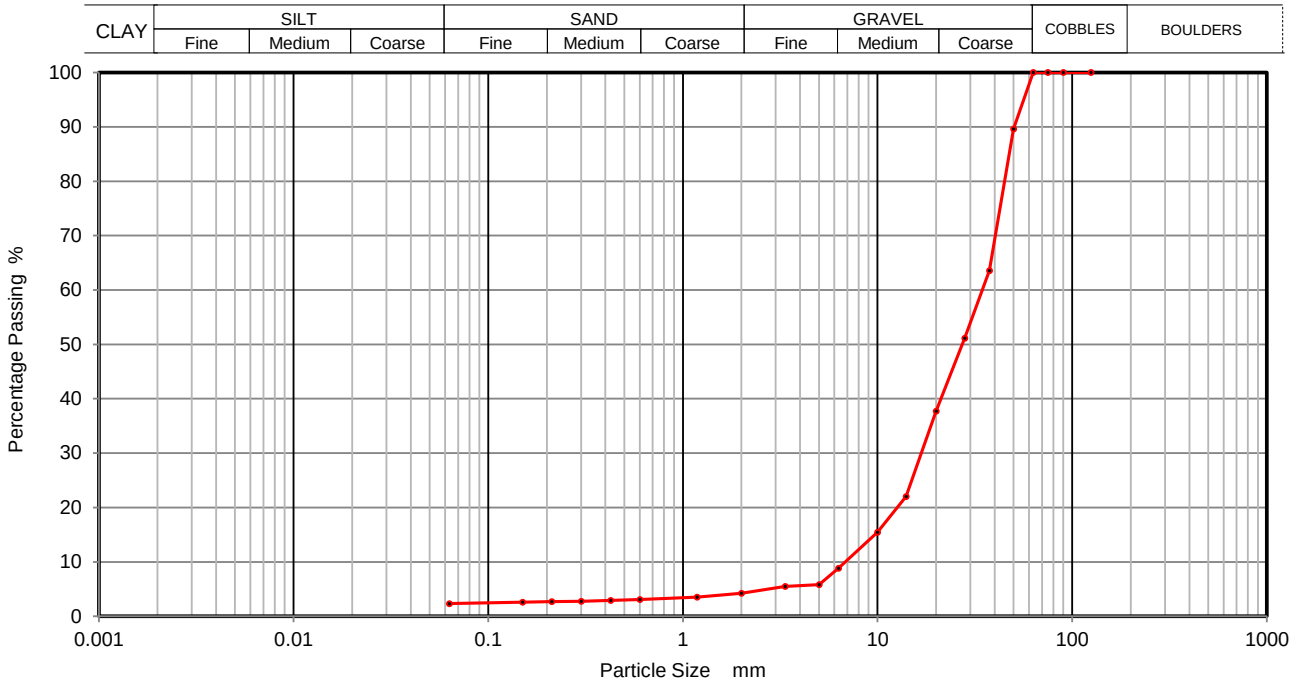
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH12
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	8.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	90		
37.5	64		
28	51		
20	38		
14	22		
10	15		
6.3	9		
5	6		
3.35	5		
2	4		
1.18	4		
0.6	3		
0.425	3		
0.3	3		
0.212	3		
0.15	3		
0.063	2		

Sample Proportions	% dry mass
Cobbles	0
Gravel	96
Sand	2
Silt and Clay	2

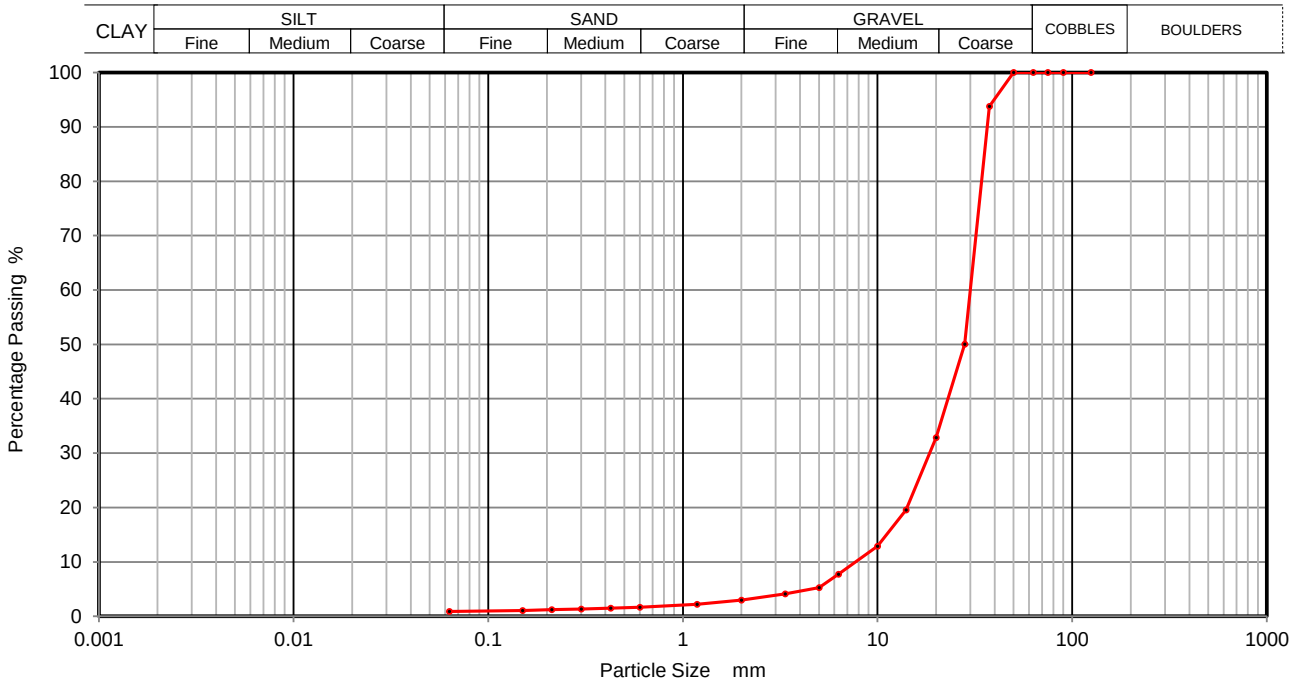
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH13
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	8.50
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	94		
28	50		
20	33		
14	20		
10	13		
6.3	8		
5	5		
3.35	4		
2	3		
1.18	2		
0.6	2		
0.425	2		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	0
Gravel	97
Sand	2
Silt and Clay	1

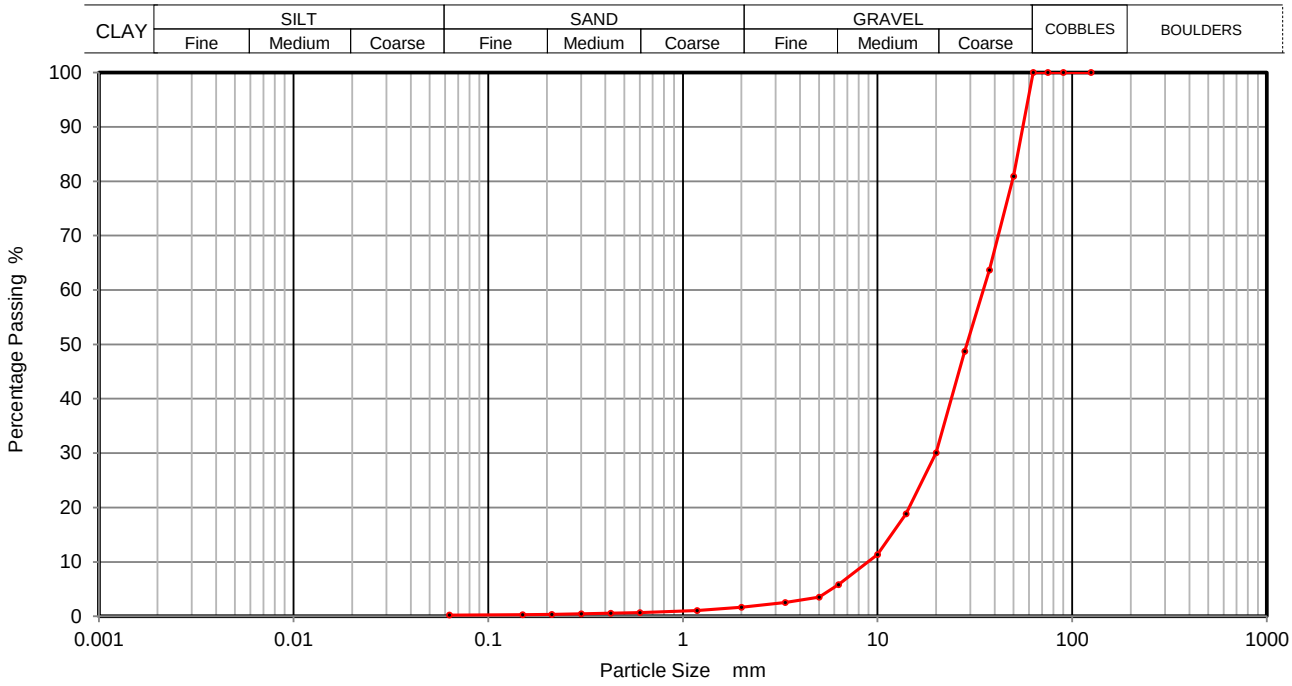
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH13
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	10.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	81		
37.5	64		
28	49		
20	30		
14	19		
10	11		
6.3	6		
5	4		
3.35	3		
2	2		
1.18	1		
0.6	1		
0.425	1		
0.3	0		
0.212	0		
0.15	0		
0.063	0		

Sample Proportions	% dry mass
Cobbles	0
Gravel	98
Sand	2
Silt and Clay	0

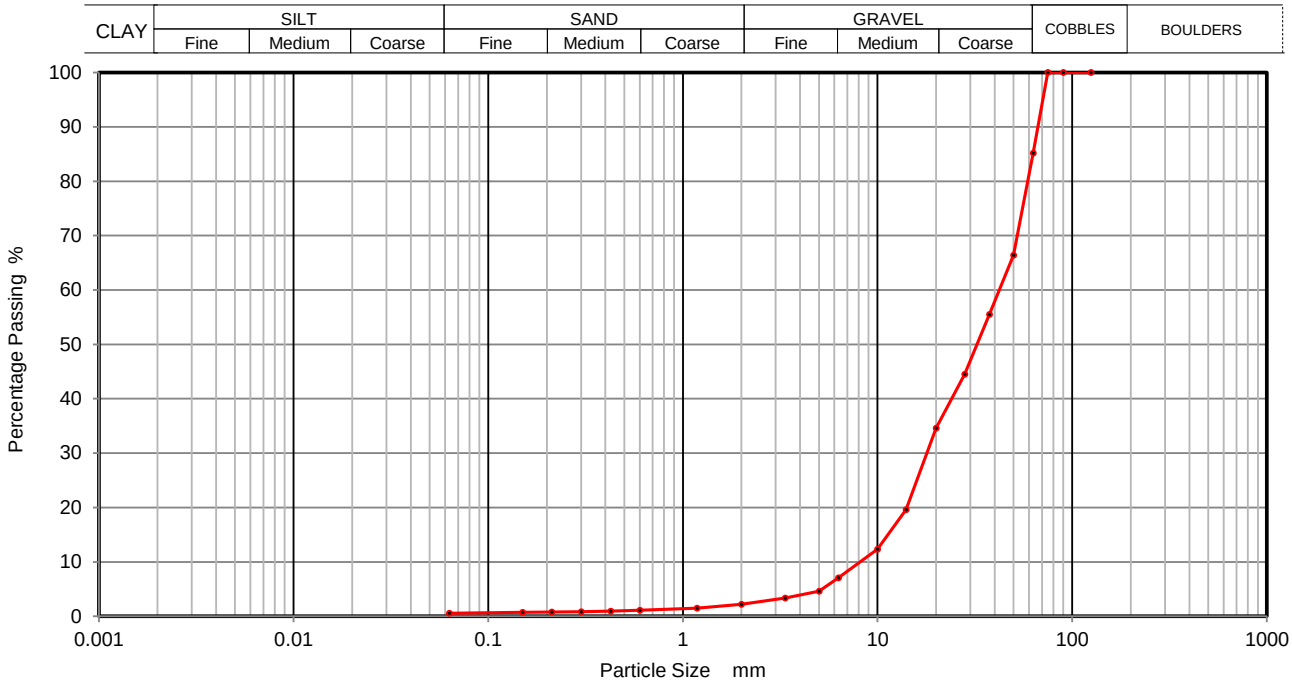
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH14
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	2.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	85		
50	66		
37.5	56		
28	45		
20	35		
14	20		
10	12		
6.3	7		
5	5		
3.35	3		
2	2		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	15
Gravel	83
Sand	1
Silt and Clay	1

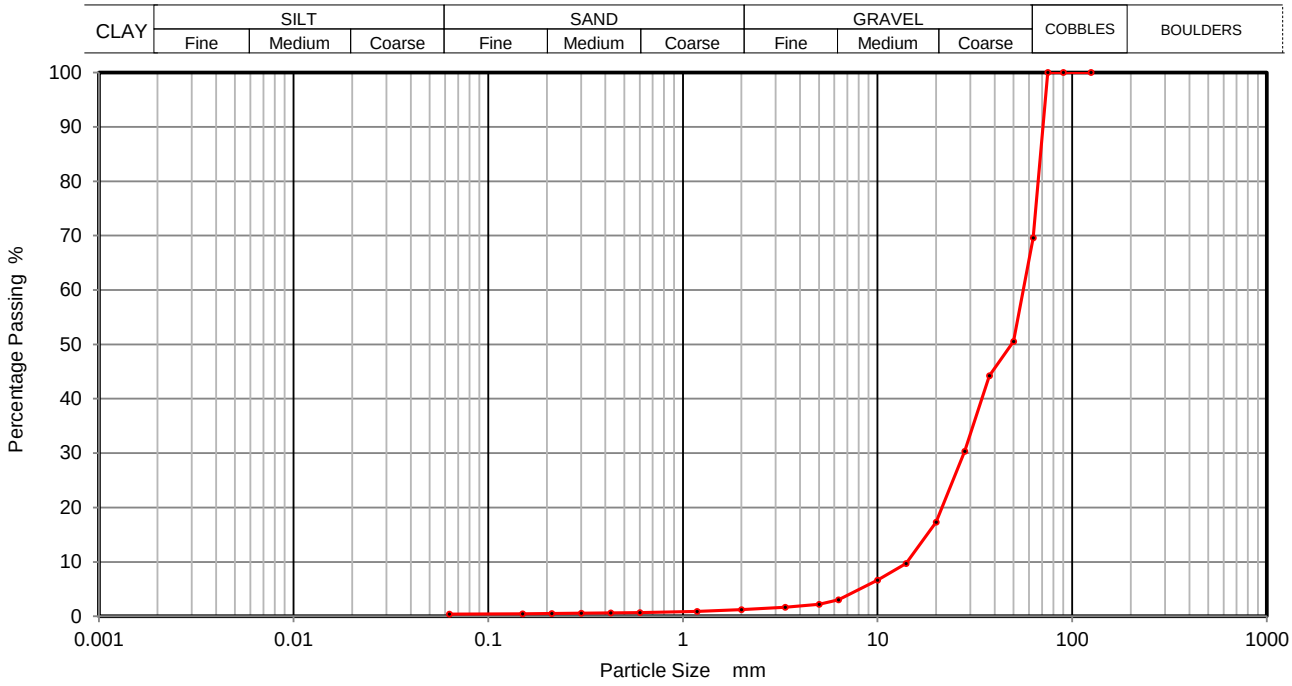
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH14
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	4.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	70		
50	51		
37.5	44		
28	30		
20	17		
14	10		
10	7		
6.3	3		
5	2		
3.35	2		
2	1		
1.18	1		
0.6	1		
0.425	1		
0.3	1		
0.212	1		
0.15	0		
0.063	0		

Sample Proportions	% dry mass
Cobbles	30
Gravel	69
Sand	1
Silt and Clay	0

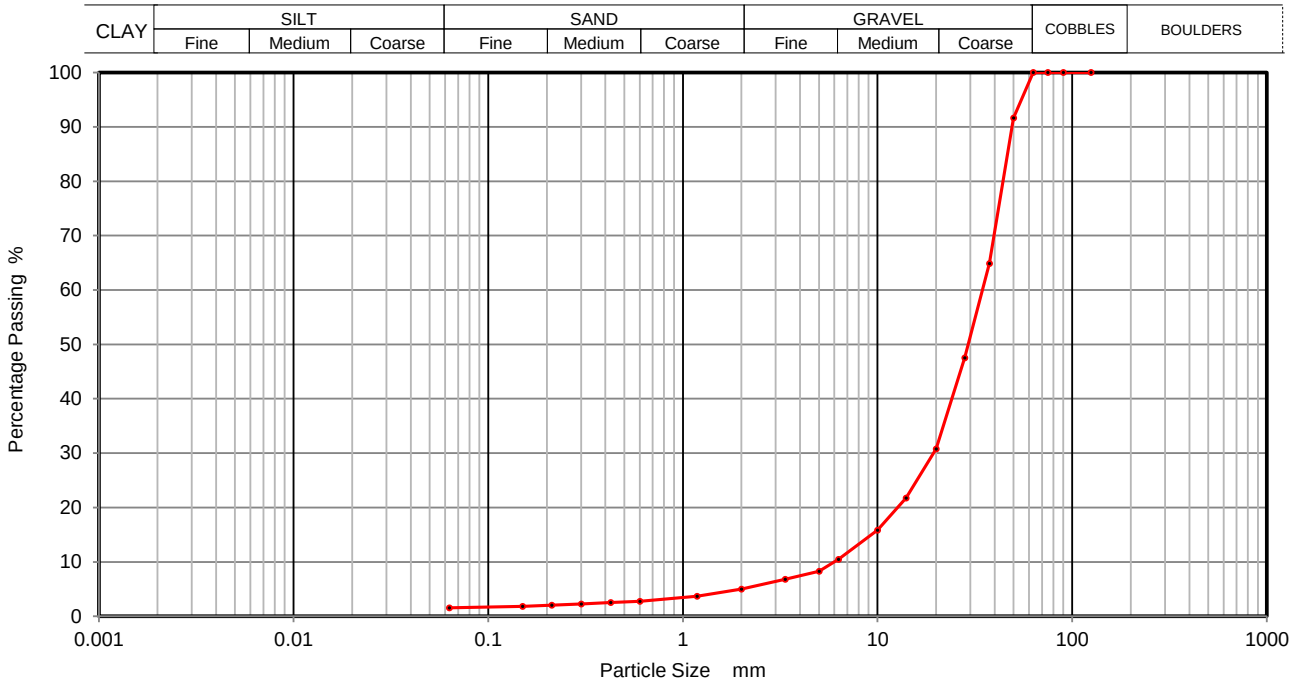
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	**PARTICLE SIZE DISTRIBUTION** **BS 1377 Part 2:1990** **Wet Sieve, Clause 9.2**	Contract Number	**46848**
		Borehole/Pit No.	**RCEBH15**
Site Name	**A40 RCE**	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	**8.00**
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	92		
37.5	65		
28	48		
20	31		
14	22		
10	16		
6.3	10		
5	8		
3.35	7		
2	5		
1.18	4		
0.6	3		
0.425	3		
0.3	2		
0.212	2		
0.15	2		
0.063	2		

Sample Proportions	% dry mass
Cobbles	0
Gravel	95
Sand	3
Silt and Clay	2

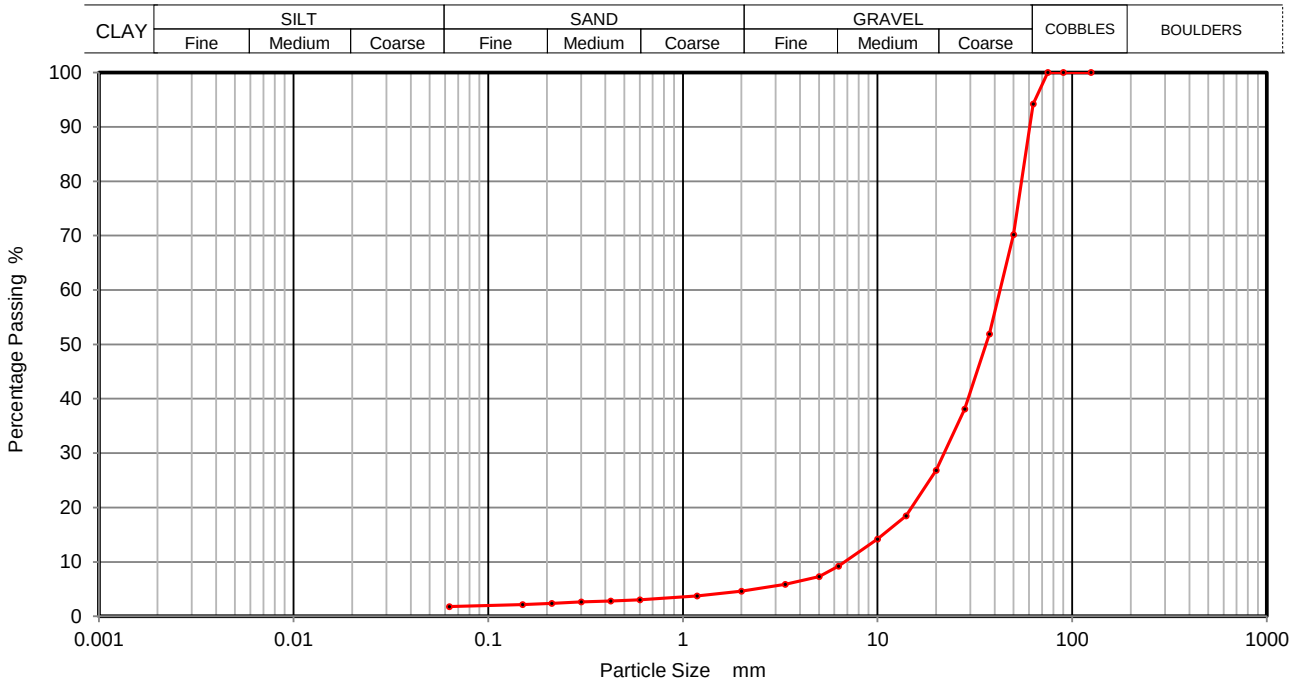
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH16
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	1.25
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	94		
50	70		
37.5	52		
28	38		
20	27		
14	18		
10	14		
6.3	9		
5	7		
3.35	6		
2	5		
1.18	4		
0.6	3		
0.425	3		
0.3	3		
0.212	2		
0.15	2		
0.063	2		

Sample Proportions	% dry mass
Cobbles	6
Gravel	89
Sand	3
Silt and Clay	2

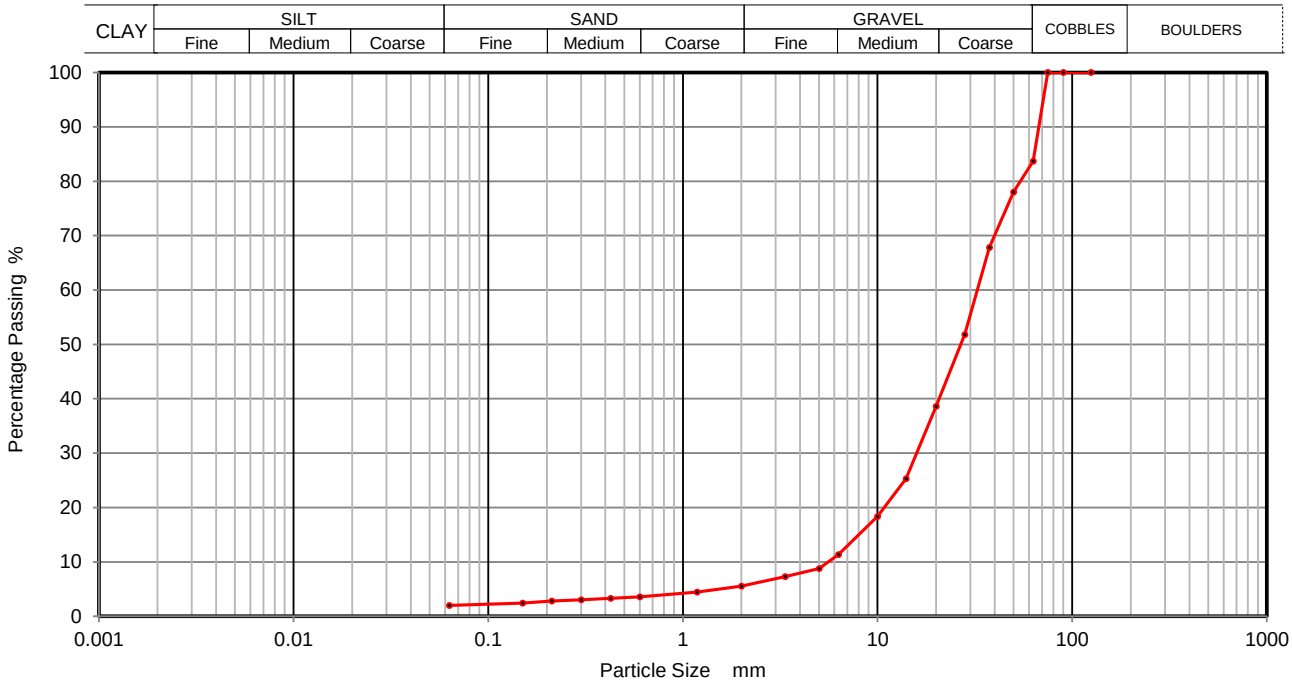
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH16
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	3.00
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	84		
50	78		
37.5	68		
28	52		
20	39		
14	25		
10	18		
6.3	11		
5	9		
3.35	7		
2	6		
1.18	4		
0.6	4		
0.425	3		
0.3	3		
0.212	3		
0.15	2		
0.063	2		

Sample Proportions	% dry mass
Cobbles	16
Gravel	78
Sand	4
Silt and Clay	2

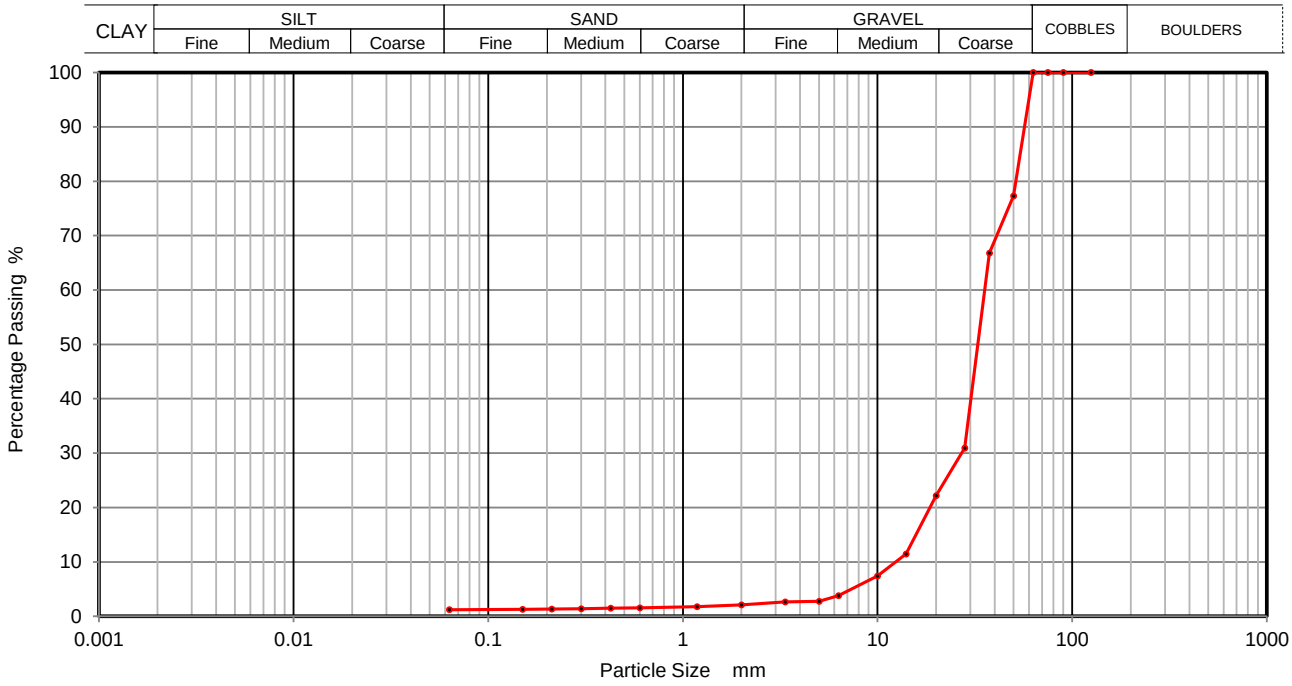
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH16
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL.	Depth Top	5.75
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	77		
37.5	67		
28	31		
20	22		
14	11		
10	7		
6.3	4		
5	3		
3.35	3		
2	2		
1.18	2		
0.6	2		
0.425	1		
0.3	1		
0.212	1		
0.15	1		
0.063	1		

Sample Proportions	% dry mass
Cobbles	0
Gravel	98
Sand	1
Silt and Clay	1

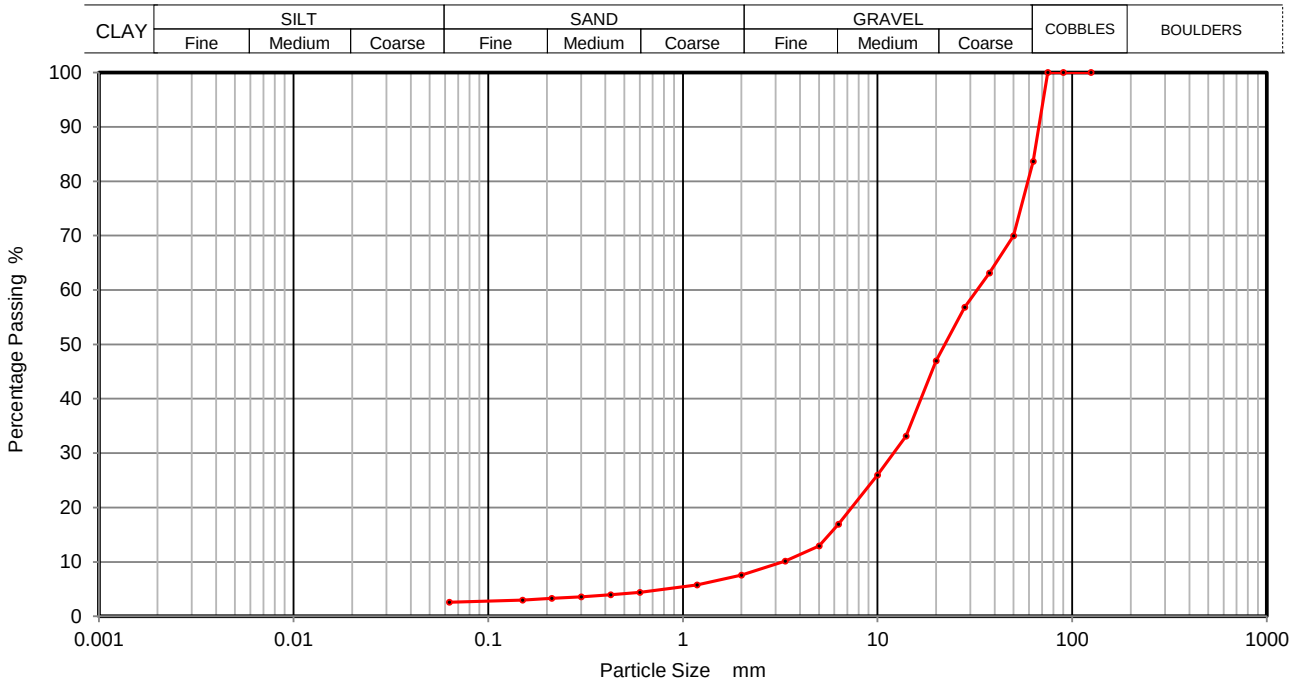
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46848
		Borehole/Pit No.	RCEBH16
Site Name	A40 RCE	Sample No.	
Soil Description	Brown silty sandy GRAVEL. With cobbles	Depth Top	8.25
		Depth Base	
Date Tested	13/12/2019	Sample Type	



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	84		
50	70		
37.5	63		
28	57		
20	47		
14	33		
10	26		
6.3	17		
5	13		
3.35	10		
2	8		
1.18	6		
0.6	4		
0.425	4		
0.3	4		
0.212	3		
0.15	3		
0.063	3		

Sample Proportions	% dry mass
Cobbles	16
Gravel	76
Sand	5
Silt and Clay	3

Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	16/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	17/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Certificate of Chemical Analysis (BRE BR 279)	Contract Number	46848
		Client Reference	Q0083
Client	Quantum	Date Received	
Site Name	A40 RCE	Date Started	06/12/2019
		Date Completed	13/12/2019
		No. of Samples	19

Hole Number	Sample Number	Sample Type	Depth (m)			Acid Soluble Sulphate	Aqueous Extract Sulphate	Chloride Content	pH Value	Total Sulphur	Magnesium	Nitrate
RCEBH01			2.50	-		0.21	0.03		7.86	0.09		
RCEBH01			5.00	-		0.19	0.04		7.54	0.08		
RCEBH02			5.00	-		0.21	0.03		7.66	0.09		
RCEBH03			2.00	-		0.19	0.03		7.39	0.08		
RCEBH03			3.00	-		0.27	0.04		7.45	0.12		
RCEBH03			4.00	-		0.21	0.04		7.61	0.09		
RCEBH04			3.00	-		0.25	0.03		7.95	0.10		
RCEBH05			6.50	-		0.29	0.05		8.04	0.12		
RCEBH05			7.50	-		0.23	0.04		8.12	0.10		
RCEBH10			2.00	-		0.31	0.03		7.18	0.13		
RCEBH10			3.50	-		0.23	0.04		7.25	0.10		
RCEBH11			2.50	-		0.23	0.03		7.69	0.10		
RCEBH11			4.75	-		0.29	0.03		7.51	0.12		
RCEBH12			7.00	-		0.33	0.04		7.84	0.13		
RCEBH12			12.00	-		0.35	0.04		8.14	0.14		
RCEBH13			7.00	-		0.29	0.04		8.01	0.13		
RCEBH13			12.00	-		0.37	0.05		8.10	0.15		
RCEBH14			4.50	-		0.29	0.05		7.63	0.12		
RCEBH16			2.00	-		0.37	0.04		7.52	0.15		
				-								
				-								
				-								
				-								
				-								
				-								
				-								
				-								
				-								
				-								
				-								

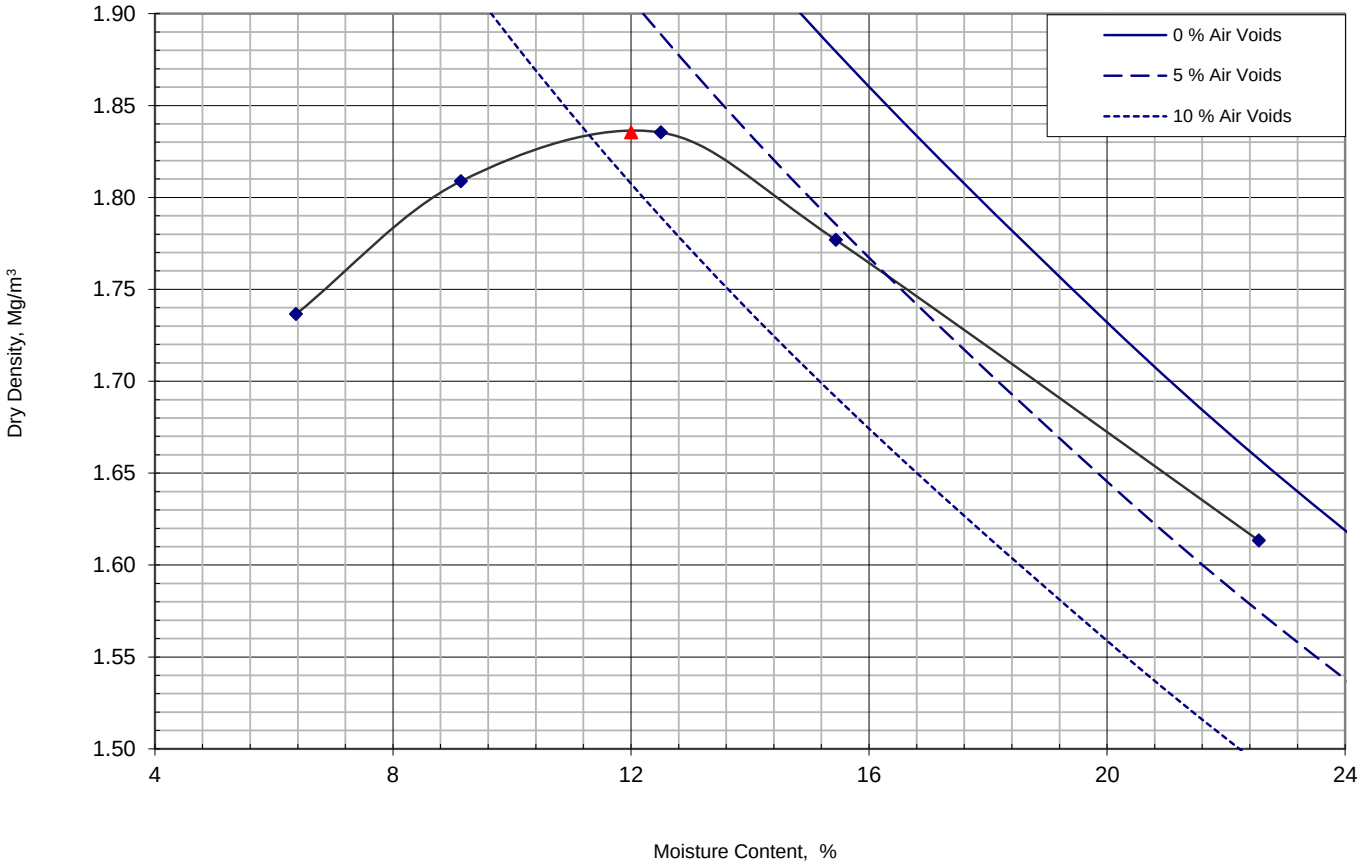
Key	Reported As
Acid Soluble Sulphate	% SO_4
Aqueous Extract Sulphate	g/l SO_4
Chloride Content (Semi)	mg Cl/l
pH Value	@ 25°
Total Sulphur	% S
Magnesium	g/l SO_4
Nitrate	NO_3 mg/l

Remarks

NCP = No Chloride Present

Test Operator	Checked and Authorised by		Paul Evans	D P Evans
Darren Bourne	Date	13/12/2019		

GSTL	Dry Density / Moisture Content Relationship BS 1377:Part 4:1990	Contract Number	46848
		Borehole / Pit No	RCE-TP19
Project Location	**A40 RCE**	Sample No	
Date Tested	**12/12/2019**	Depth Top	**0.67**
Compaction Method	**2.5 Kg Rammer**	Depth Base	**0.70**
Compaction Clause	**BS1377:Part 4:1990, Clause 3.3**	Sample Type	**B**
Sample Description	**Greyish brown sandy silty CLAY.**		



Compaction Point	1	2	3	4	5							
Moisture Content	6.4	9.1	13	15	23							
Bulk Density	1.85	1.97	2.06	2.05	1.98							
Dry Density	1.74	1.81	1.84	1.78	1.61							

Initial Moisture Content	23	%
Maximum Dry Density	1.84	Mg/m3
Optimum Moisture Content	12	%
Particle Density	2.65 Assumed	Mg/m3
Material Retained 37.5mm	0	%
Material Retained 20mm	0	%

Operators	Checked	12/12/2019	Emma Sharp	
CA	Approved	13/12/2019	Paul Evans	

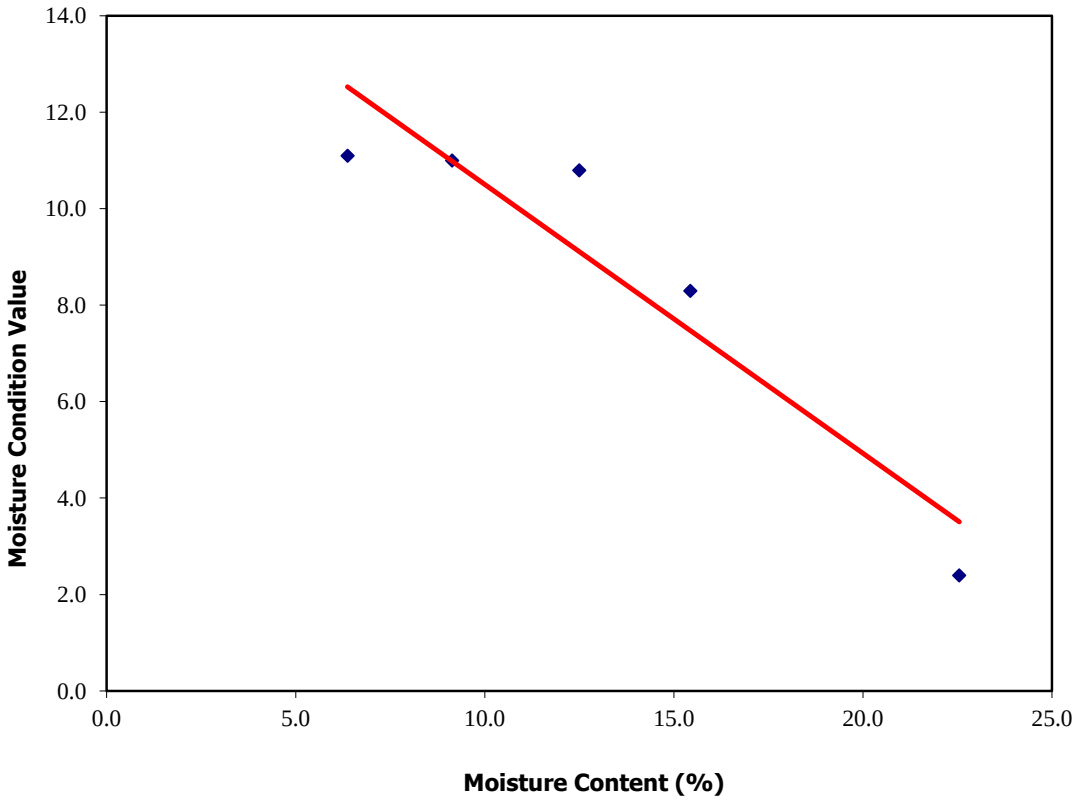
UKAS TESTING
2788

Moisture Condition Value Calibration

BS 1377:Part 4:1990

Client ref:	**Q0083**
Location:	**A40 RCE**
Contract Number:	**46848**
Hole Number:	**RCE-TP19**
Sample Number:	
Depth (m) :	**0.67-0.70**
Sample Type	**B**

Initial Moisture Content (%).:	22.6
Single/Separate Samples Tested.	Single
Material Retained on the 20mm BS Test Sieve (%):	0



Test Results.

Test Number.	1	2	3	4	5
Moisture Content (%).	6.4	9.1	12.5	15.4	22.6
MCV	11.1	11.0	10.8	8.3	2.4

*** reading unobtainable.**

GSTL
GEO SITE & TESTING SERVICES LTD

Checked by
Emma Sharp
Date approved:

Approved by
Paul Evans (Office Manager)
13/12/19

UKAS TESTING
2788

Test Report: CONSOLIDATED DRAINED SHEARBOX TEST.

BS1377:Part 7:4.5 :1990.

Borehole Number:	RCETP5	Depth from (m):	3.00
Sample Number :	7	Depth to (m):	3.10

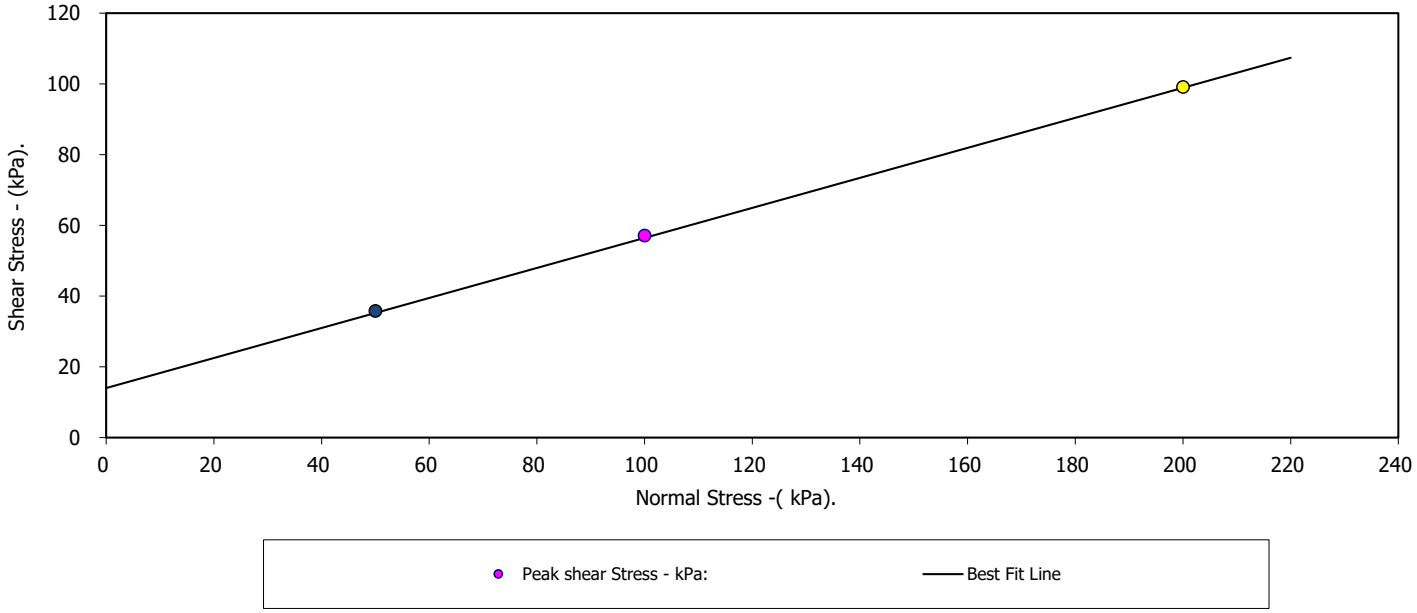
Sample Type:	B
Particle Density - Mg/m3:	2.65 (Assumed)
Specimen Tested:	Submerged, Remoulded (Light Tamping) Material above 2mm removed.

Sample Description:
Brown CLAY

STAGE	**1**	**2**	**3**
Initial Conditions			
Height - mm:	23.98	23.98	23.98
Length - mm:	60.00	60.00	60.00
Moisture Content - %:	30	30	30
Bulk Density - Mg/m3:	1.94	1.94	1.94
Dry Density - Mg/m3:	1.49	1.49	1.49
Voids Ratio:	0.7759	0.7759	0.7759
Normal Pressure- kPa	50	100	200
Consolidation			
Consolidated Height - mm:	23.72	23.27	22.83
Shear			
Rate of Strain (mm/min)	0.010	0.010	0.010
Strain at peak shear stress (mm)	6.49	6.12	6.17
Peak shear Stress - kPa:	36	57	99

PEAK	
Angle of Shearing Resistance:(θ)	**23.0**
Effective Cohesion - kPa:	**14**

FAILURE CONDITIONS



D P Evans 17-12-19
Checked Pages 1-4 by: Date:

D P Evans 17-12-19
Approved Pages 1-4 by: Date

Contract No.:
46848

A40 RCE

Client Ref Number:

Q0083

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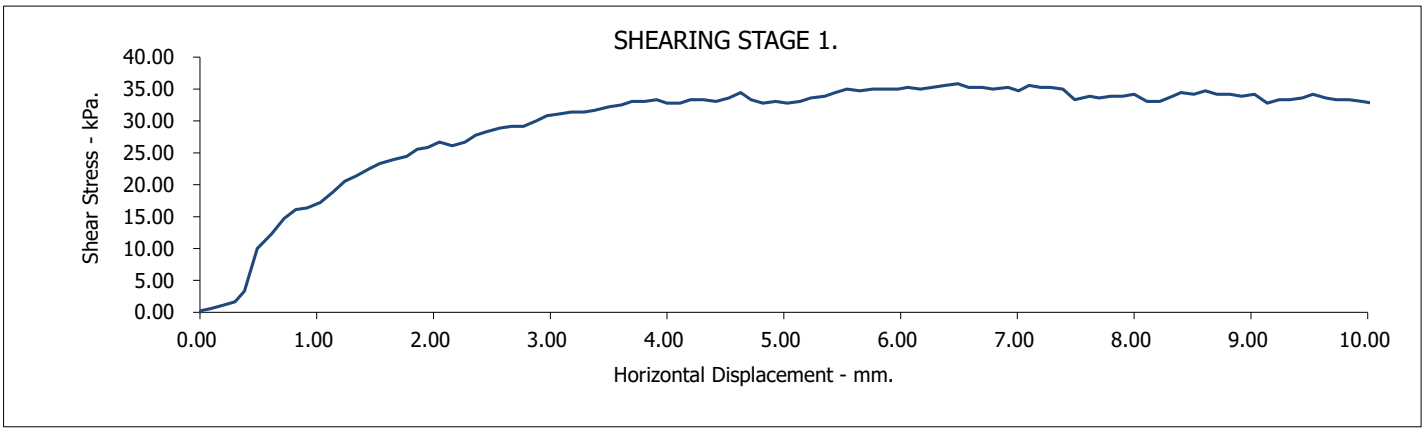
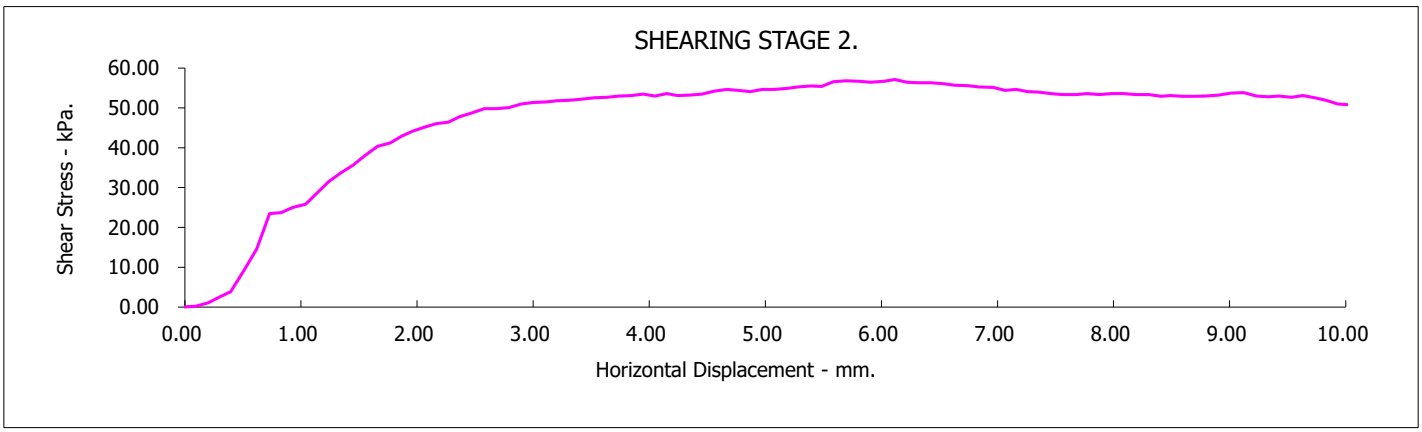
GEO SITE & TESTING SERVICES LTD

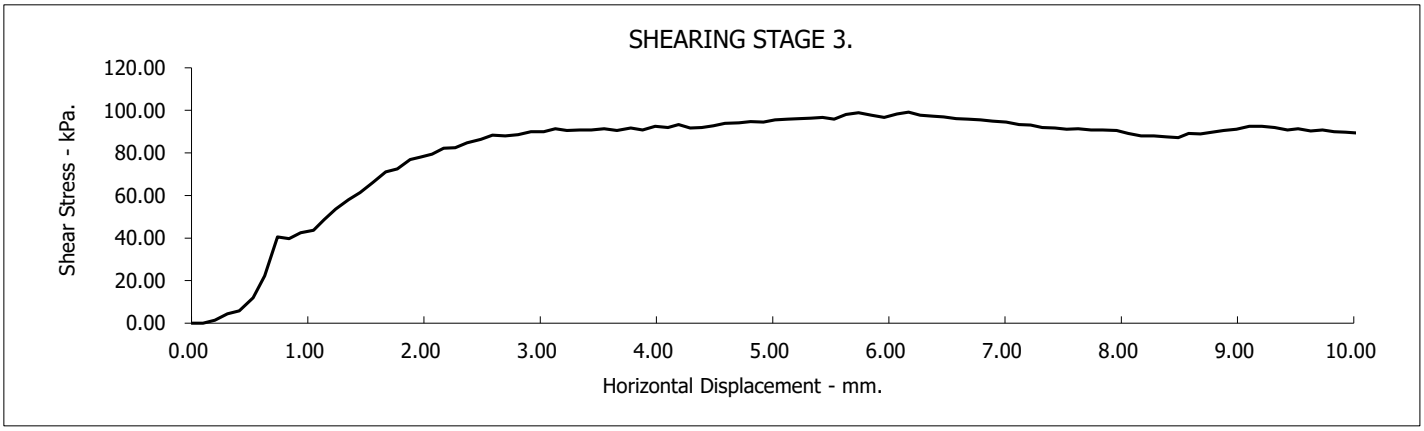
Test Report: CONSOLIDATED DRAINED SHEARBOX TEST.

BS1377:Part 7:4.5 :1990.

Borehole Number:	RCETP5	Depth from (m):	3.00
Sample Number :	7	Depth to (m):	3.10







A40 RCE

Contract No.: **46848**

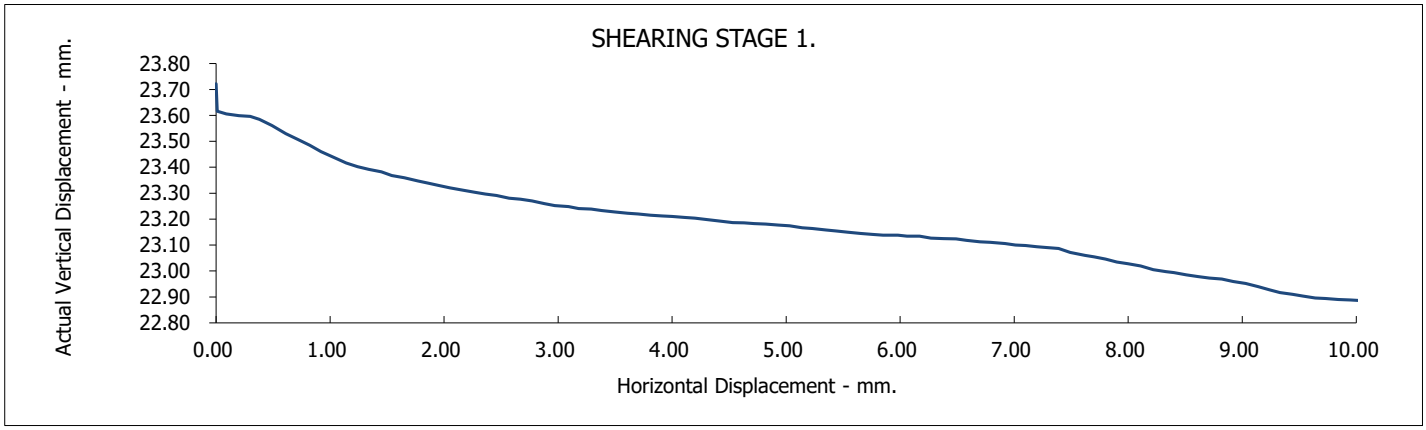
Client Ref Number: **Q0083**

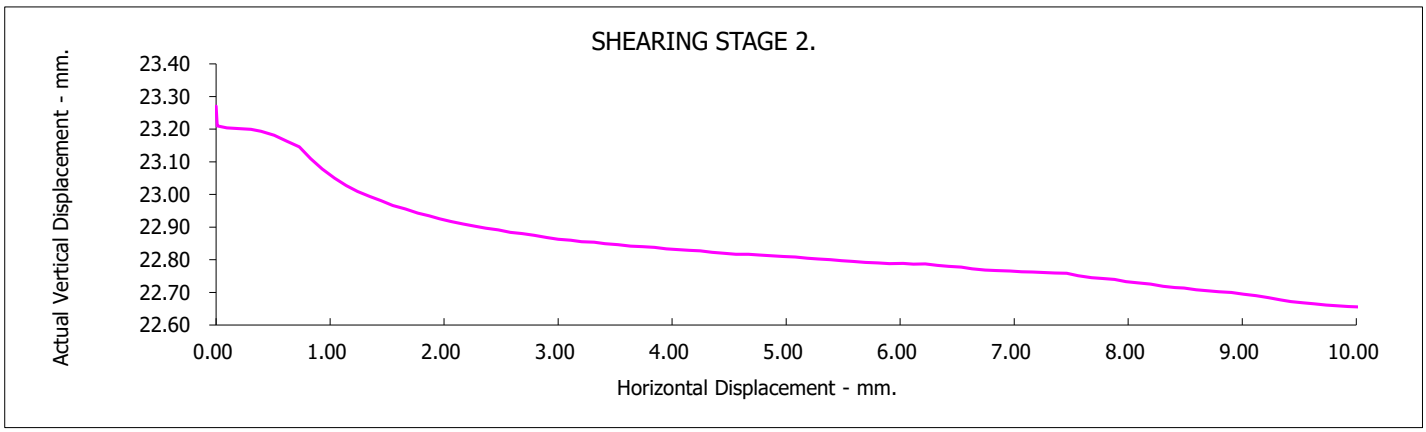
Figure.

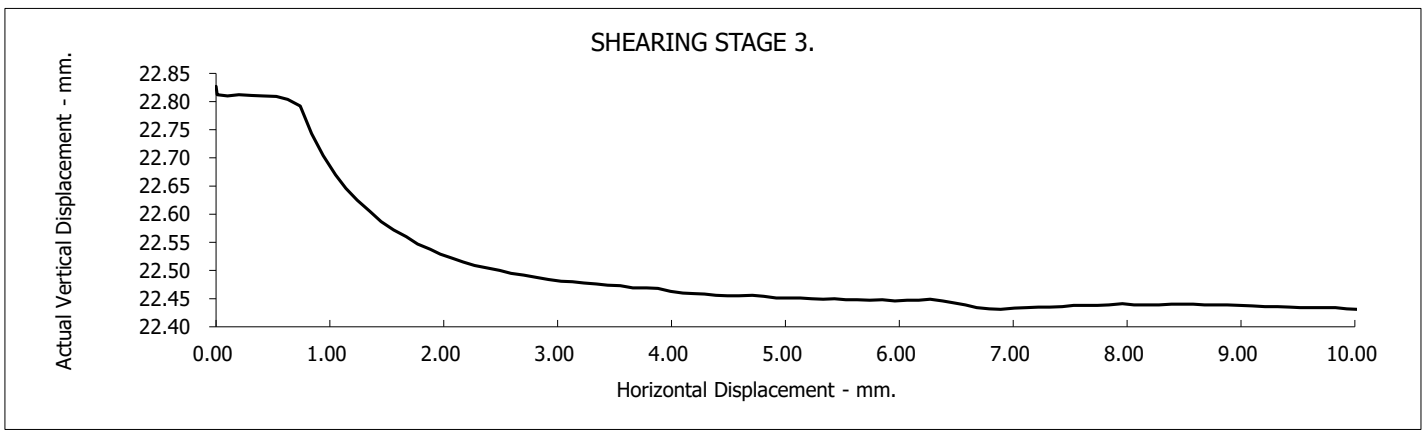
Test Report: CONSOLIDATED DRAINED SHEARBOX TEST.

BS1377:Part 7:4.5 :1990.

Borehole Number:	RCETP5	Depth from (m):	3.00
Sample Number :	7	Depth to (m):	3.10







Contract No.:
46848

A40 RCE

Client Ref Number:
Q0083

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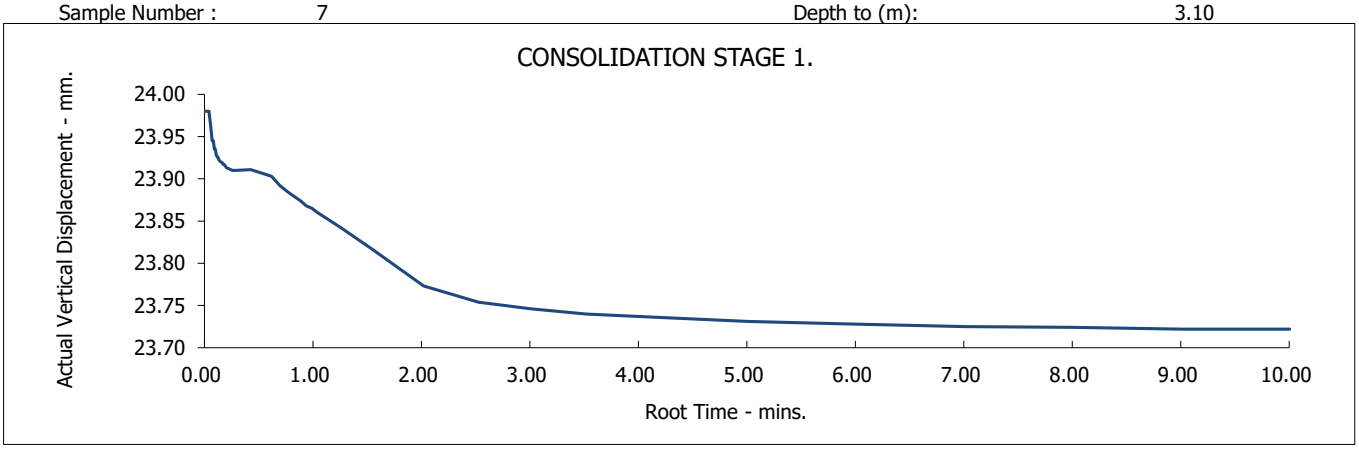
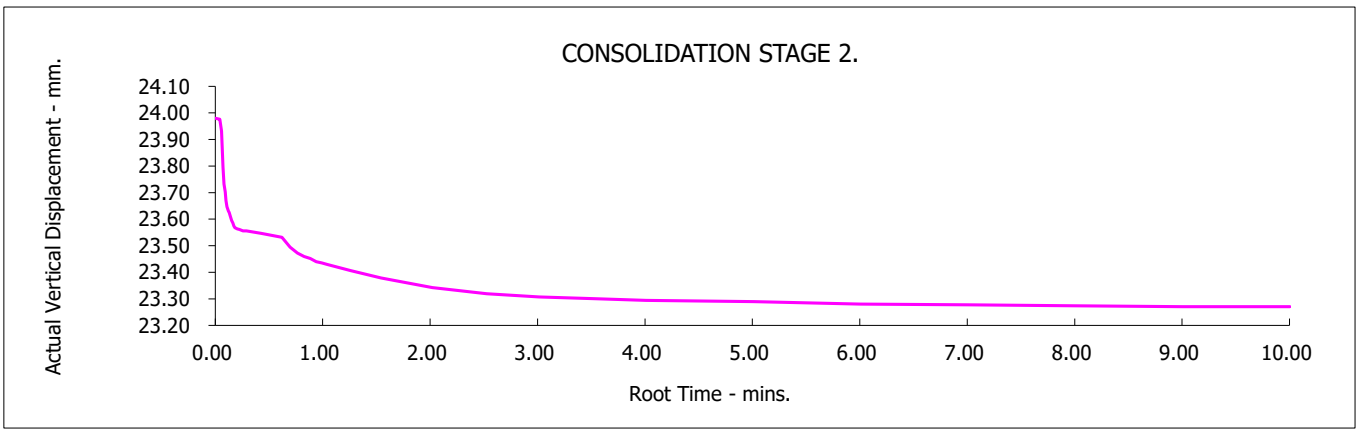
GEO SITE & TESTING SERVICES LTD

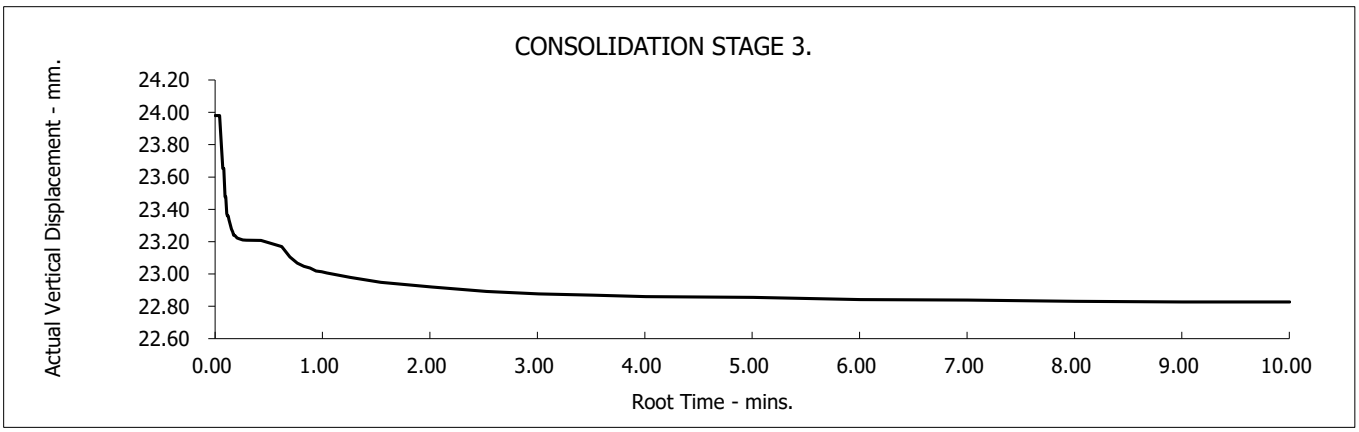
Test Report: CONSOLIDATED DRAINED SHEARBOX TEST.

BS1377:Part 7:4.5 :1990.

Borehole Number:	RCETP5	Depth from (m):	3.00
Sample Number :	7	Depth to (m):	3.10







Contract No.:
46848

A40 RCE

Client Ref Number:
Q0083

Shearing test - Direct shearing
BS 1377 part 7

Location :	A40 RCE	Sampling date :	13/12/2019
Technician's name :	Brendan Evans	Date of test :	13/12/2019
Job N° :	46848	Depth (m) :	0.30 / 0.50
BH/TP N° :	RCE TP7	Quotation (m) :	0.00 / 0.00
Soil type :	CLAY	Level of water (m) :	

GSTL

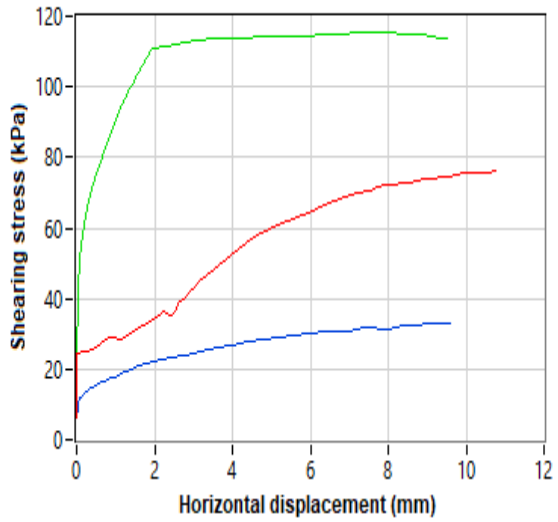
Dafen HQ and Stores - Unit 4 , Heol Aur , Dafen Ind Estate , Dafen , Llanelli , Carmarthenshire SA14

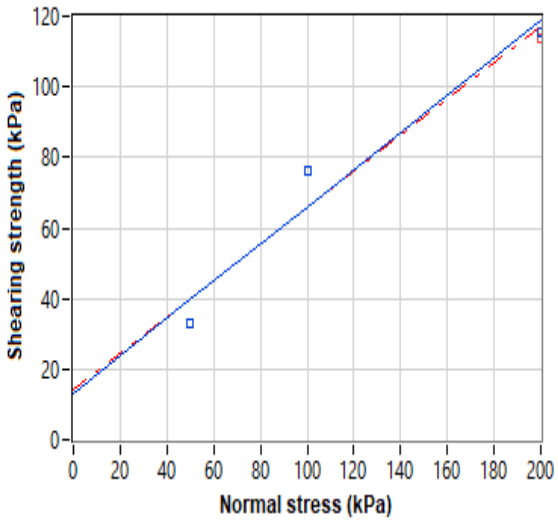
Samples before / after test

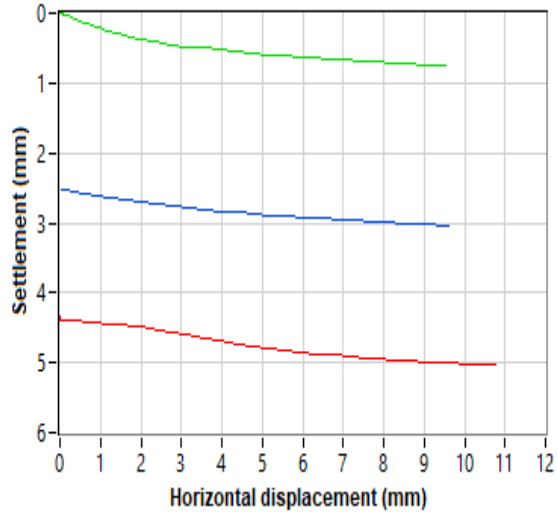
D or L, Sample's diameter or width (mm) :	60.00	ρs, Estimated grain density (kg/m³) :	2650
svo, Total stress of the soil in situ (kPa) :	5	Uo, Pore pressure of the soil in situ (kPa) :	0
s'vo, Effective stress of the soil in situ (kPa) :	5	Shearing speed (µm/min) :	0.1

N°	Hi (mm)	mi (g)	ρi (kg/m³)	ρdi (kg/m³)	wi (%)	ei	Sri (%)	T100 (min)	ρdf (kg/m³)	wf (%)	σ' (kPa)	τ f,p (kPa)	δl f,p (mm)	τ f,f (kPa)	δl f,f (mm)
1	23.22	140.7	1684	1088	54.7	1.435	101.0	3000	1189	NaN	50.0	32.8	8.99	32.8	9.60
2	23.22	140.8	1684	1088	54.7	1.435	101.0	1800	1323	NaN	100.0	76.4	10.75	76.4	10.75
3	23.75	141.8	1659	1072	54.7	1.471	98.5	3600	1324	NaN	200.0	115.6	7.52	113.9	9.52

Shearing and settlement graphs







Results

C'p (kPa)	C'f (kPa)	φ'p (°)	φ'f (°)
13	14	27	27

Description

Brown sandy silty CLAY

Shearing test - Direct shearing
BS 1377 part 7

Location :	A40 RCE	Sampling date :	16/12/2019
Technician's name :	Brendan Evans	Date of test :	13/12/2019
Job N° :	46848	Depth (m) :	1.00 / 0.00
BH/TP N° :	RCE TP7	Quotation (m) :	0.00 / 0.00
Soil type :	CLAY	Level of water (m) :	

GSTL

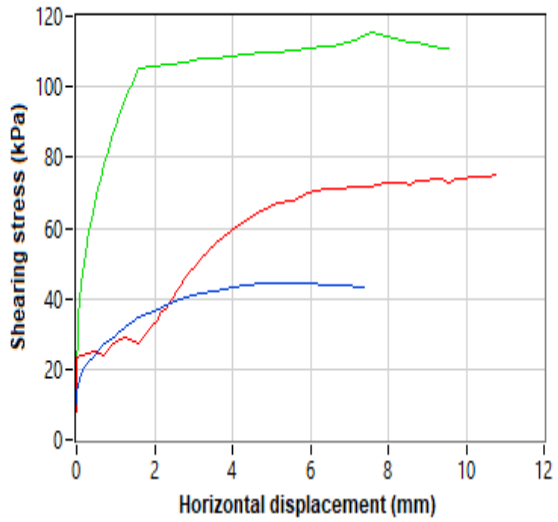
Dafen HQ and Stores - Unit 4 , Heol Aur , Dafen Ind Estate , Dafen , Llanelli , Carmarthenshire SA14

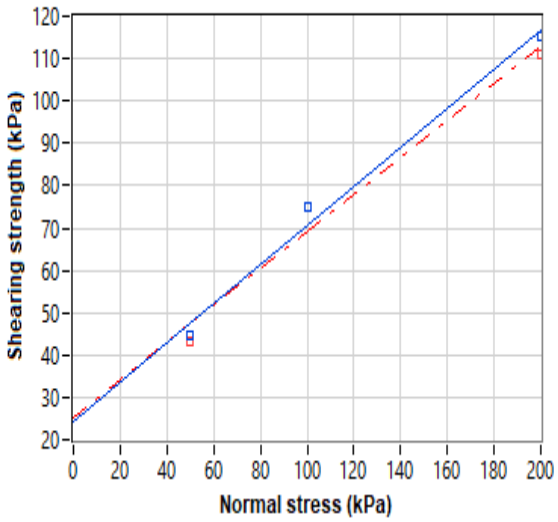
Samples before / after test

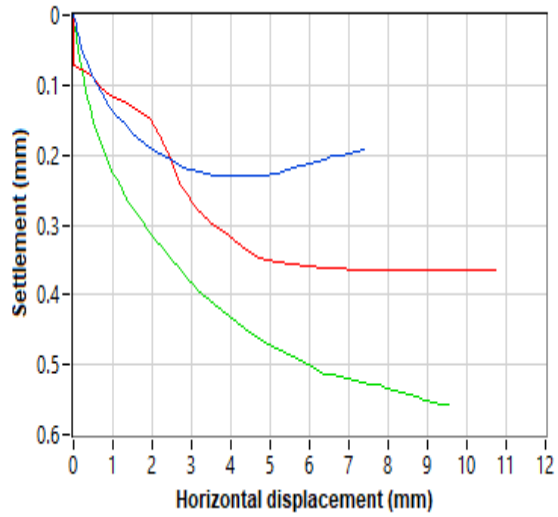
D or L, Sample's diameter or width (mm) :	60.00	ρs, Estimated grain density (kg/m³) :	2650
svo, Total stress of the soil in situ (kPa) :	20	Uo, Pore pressure of the soil in situ (kPa) :	0
s'vo, Effective stress of the soil in situ (kPa) :	20	Shearing speed (µm/min) :	0.1

N°	Hi (mm)	mi (g)	ρi (kg/m³)	ρdi (kg/m³)	wi (%)	ei	Sri (%)	T100 (min)	ρdf (kg/m³)	wf (%)	σ' (kPa)	τ f,p (kPa)	δl f,p (mm)	τ f,f (kPa)	δl f,f (mm)
1	23.75	170.1	1989	1525	30.4	0.738	109.4	3600	1617	NaN	50.0	44.4	4.79	43.3	7.39
2	23.75	169.1	1978	1516	30.4	0.748	107.9	3600	1640	NaN	100.0	75.0	10.74	75.0	10.74
3	23.22	169.8	2032	1558	30.4	0.701	115.0	3600	1768	NaN	200.0	115.3	7.55	110.8	9.55

Shearing and settlement graphs







Results

C'p (kPa)	C'f (kPa)	φ'p (°)	φ'f (°)
24	25	24	23

Description

Brown CLAY

GSTL	Point Load Test Int. J. Rock Mech. Sci. & Geomech. Abstr. Vol. 22, No. 2, pp. 51 - 60, 1985.	
Contract Number	46848	
Site Name	A40 RCE	
Sample Type	Core	
Date Tested	06/12/2019	
	*Please note that GSTL is not accredited for the water content of rock	

Hole Reference	Depth (m)			Test Type		Width	Platen Seperation	Failure Load	Equivalent Diameter	Point Load	Size Factor	Point Load Index	Moisture Content	Description	Angle Between Plane of Anisotropy & Core Axis	Type of Anisotropy (Bedding or Cleavage)
				d / a / b / i	I //											
RCEBH01	4.00	-		d			72.1	14.34		2.76	1.18	3.25	2.0	SILTSTONE		
RCEBH01	7.00	-		d			72.4	3.17		0.60	1.18	0.71	1.4	SILTSTONE		
RCEBH02	7.00	-		d			72.4	0.56		0.11	1.18	0.13	4.3	SILTSTONE		
RCEBH02	11.50	-		a		72.2	52.8	1.88	69.67	0.39	1.16	0.45	3.1	SILTSTONE		
RCEBH03	3.00	-		d			72.3	1.22		0.23	1.18	0.28	3.2	SILTSTONE		
RCEBH03	5.00	-		d			72	12.37		2.39	1.18	2.81	1.9	SILTSTONE		
RCEBH03	10.00	-		d			72.1	0.96		0.18	1.18	0.22	1.2	SILTSTONE		
RCEBH04	3.00	-		d			70.4	1.24		0.25	1.17	0.29	5.0	SILTSTONE		
RCEBH04	6.50	-		d			72.1	0.71		0.14	1.18	0.16	4.3	SILTSTONE		
RCEBH04	11.00	-		d			72.2	2.92		0.56	1.18	0.66	2.1	SILTSTONE		
RCEBH05	7.50	-		a		71.6	51.2	0.31	68.32	0.07	1.15	0.08	5.4	SILTSTONE		
RCEBH05	10.00	-		a		70.3	25.3	0.19	47.59	0.08	0.98	0.08	4.4	SILTSTONE		
RCEBH05	13.00	-		i		70	61.3	9.00	73.92	1.65	1.19	1.96	4.1	SILTSTONE		
RCEBH06	9.50	-		d			72	13.99		2.70	1.18	3.18	0.2	SILTSTONE		
RCEBH08	13.00	-		d			72.2	1.14		0.22	1.18	0.26	2.3	SILTSTONE		
RCEBH09	4.50	-		d			71.9	4.22		0.82	1.18	0.96	3.4	SILTSTONE		
RCEBH09	8.50	-		d			72.1	1.34		0.26	1.18	0.30	2.7	SILTSTONE		
RCEBH10	1.50	-		a		72	42.7	0.62	62.57	0.16	1.11	0.17	2.0	SILTSTONE		
RCEBH10	3.50	-		a		72.2	52.3	0.66	69.34	0.14	1.16	0.16	3.2	SILTSTONE		
RCEBH10	6.00	-		d			71.7	0.11		0.02	1.18	0.02	2.9	SILTSTONE		
RCEBH10	10.00	-		d			72.1	0.08		0.02	1.18	0.02	2.4	SILTSTONE		
RCEBH11	4.50	-		a		72.1	48.2	1.10	66.52	0.25	1.14	0.28	2.5	SILTSTONE		
RCEBH11	6.50	-		d			72	1.24		0.24	1.18	0.28	2.7	SILTSTONE		
RCEBH12	5.00	-		d			72	0.18		0.03	1.18	0.04	6.1	SILTSTONE		
RCEBH12	11.00	-		d			72.2	0.23		0.04	1.18	0.05	1.2	SILTSTONE		
RCEBH13	9.00	-		d			72.1	5.23		1.01	1.18	1.19	1.2	SILTSTONE		
RCEBH13	6.00	-		a		71.9	38.6	1.05	59.44	0.30	1.08	0.32	2.2	SILTSTONE		
RCEBH13	11.50	-		d			72	4.38		0.84	1.18	0.99	1.2	SILTSTONE		
RCEBH14	6.00	-		a		71.5	38.6	0.30	59.28	0.08	1.08	0.09	3.2	SILTSTONE		
RCEBH14	8.00	-		d			72.2	0.06		0.01	1.18	0.01	2.1	SILTSTONE		
RCEBH15	10.00	-		d			72.1	1.18		0.23	1.18	0.27	2.1	SILTSTONE		
RCEBH16	2.00	-		a		72.7	30.7	0.20	53.31	0.07	1.03	0.07	3.7	SILTSTONE		
RCEBH16	5.00	-		d			71.9	1.11		0.21	1.18	0.25	3.8	SILTSTONE		
RCEBH16	8.00	-		d			72.3	0.18		0.03	1.18	0.04	1.5	SILTSTONE		
		-														
		-														
		-											

Laboratory Report

2788

GEO Site & Testing Services Ltd

Contract Number: 46875

Client Ref: **Q0083**
Client PO:

Report Date: **19-12-2019**

Client **Quantum Geotechnic Ltd**
Ty Berwig
Bynea
Llanelli.
Carmarthenshire.
SA14 9ST

Contract Title: **A40 RCE**
For the attention of: **Hugh Woodroffe**

Date Received: **03-12-2019**
Date Completed: **19-12-2019**

Test Description	Qty
Moisture Content BS 1377:1990 - Part 2 : 3.2 - * UKAS	16
4 Point Liquid & Plastic Limit BS 1377:1990 - Part 2 : 4.3 & 5.3 - * UKAS	16
PSD Wet Sieve method BS 1377:1990 - Part 2 : 9.2 - * UKAS	8
PSD: Sedimentation by pipette carried out separately BS 1377:1990 - Part 2 : 9.4 - * UKAS	8
BRE Suite B Greenfield Site (pyrite present) **includes pH, water & acid soluble sulphate and total sulphur** BRE - BR279 - @ Non Accredited Test	6
Disposal of samples for job	1

Notes: **Observations and Interpretations are outside the UKAS Accreditation**
*** - denotes test included in laboratory scope of accreditation**
 # - denotes test carried out by approved contractor
@ - denotes non accredited tests

This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced except in full, without the prior written approval of the laboratory.

Approved Signatories:
Emma Sharp (Office Manager) - Paul Evans (Quality/Technical Manager) - Richard John (Advanced Testing Manager)
Sean Penn (Administrative/Accounts Assistant) - Shaun Jones (Laboratory manager) - Wayne Honey (Administrative/Quality Assistant)

GEO Site & Testing Services Ltd
Unit 3-4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46875	
Site Name	A40 RCE	
Date Tested	12/12/2019	
	DESCRIPTIONS	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Descriptions
RCEDS01	1	WS	0.50	-		Brown clayey silty sandy GRAVEL.
RCEDS01	2	WS	1.20	-		Brown gravelly sandy silty CLAY.
RCEDS02	1	WS	0.70	-		Brown clayey silty sandy GRAVEL.
RCEDS03	1	WS	0.40	-		Brown clayey silty sandy GRAVEL.
RCEDS04	1	WS	0.50	-		Brown gravelly silty CLAY.
RCEDS04	1	WS	0.70	-		Brown clayey silty sandy GRAVEL.
RCEDS05	3	B	0.30	-	0.70	Brown gravelly silty CLAY.
RCEDS05	3	D	1.00	-	1.30	Brown clayey silty sandy GRAVEL.
RCEDS05	4	D	1.60	-	1.90	Brown gravelly silty CLAY.
RCEDS05	5	D	2.00	-	2.10	Brown gravelly silty CLAY.
RCEDS06a	1	WS	0.40	-		Brown gravelly silty CLAY.
RCEDS06a	1	WS	0.60	-		Brown gravelly sandy silty CLAY.
RCEDS07	1	WS	0.50	-		Brown gravelly silty CLAY.
RCEDS08	1	WS	0.50	-		Brown gravelly silty CLAY.
RCEDS10	1	WS	0.30	-		Brown gravelly silty CLAY.
RCEDS10	1	WS	0.70	-		Brown gravelly sandy silty CLAY.
				-		
				-		
				-		
				-		
				-		
				-		
				-		
				-		

Operators	Checked	19/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	19/12/2019	Paul Evans (Quality/Technical Manager)

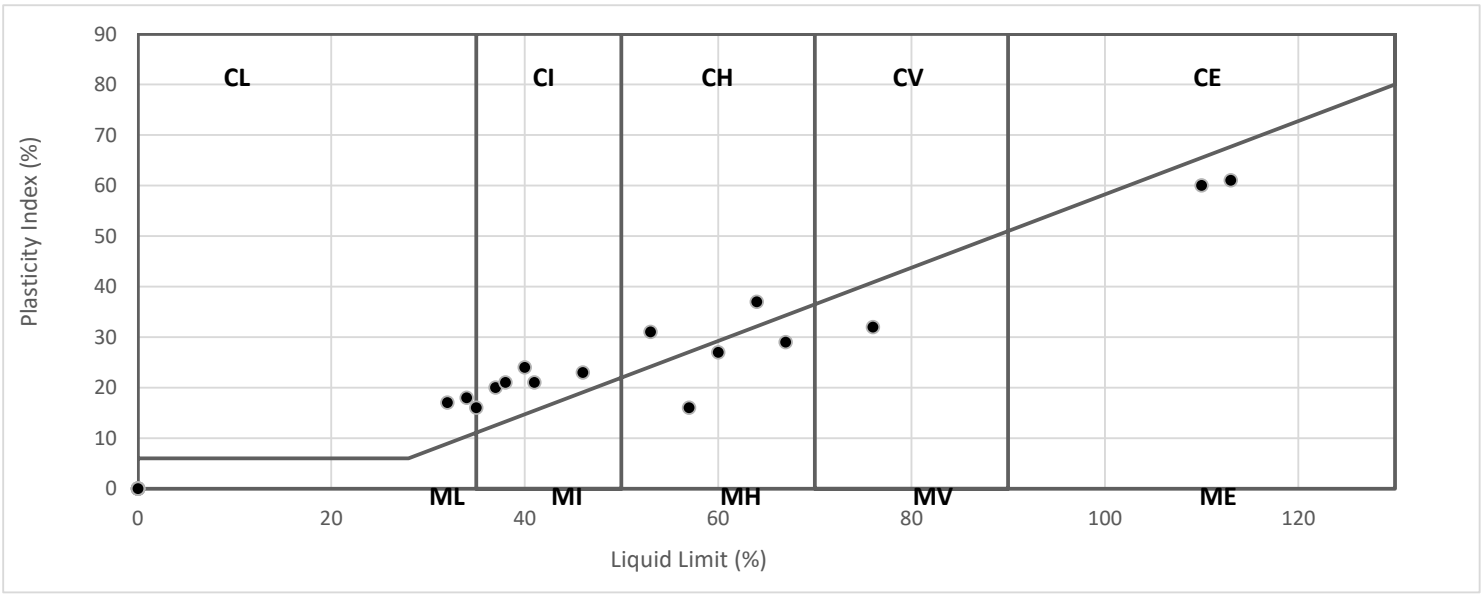
UKAS TESTING
2788

GSTL	NATURAL MOISTURE, LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX (BS 1377 : Part 2 : 1990 Method 5)	
Contract Number	46875	
Project Location	A40 RCE	
Date Tested	12/12/2019	

Sample/Hole Reference	Sample Number	Sample Type	Depth (m)			Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity index %	Passing 0.425mm %	Remarks
RCEDS01	1	WS	0.50	-		64	113	52	61	21	ME Extremely High Plasticity
RCEDS01	2	WS	1.20	-		59	110	50	60	86	ME Extremely High Plasticity
RCEDS02	1	WS	0.70	-		19	40	16	24	25	CI Intermediate Plasticity
RCEDS03	1	WS	0.40	-		35	57	41	16	29	MH High Plasticity
RCEDS04	1	WS	0.50	-		31	60	33	27	85	MH High Plasticity
RCEDS04	1	WS	0.70	-		16	32	15	17	27	CL Low Plasticity
RCEDS05	3	B	0.30	-	0.70	34	67	38	29	80	MH High Plasticity
RCEDS05	3	D	1.00	-	1.30	17	35	19	16	18	CL/I Low/Inter. Plasticity
RCEDS05	4	D	1.60	-	1.90	32	64	27	37	82	CH High Plasticity
RCEDS05	5	D	2.00	-	2.10	20	37	17	20	78	CI Intermediate Plasticity
RCEDS06a	1	WS	0.40	-		48	76	44	32	90	MV Very High Plasticity
RCEDS06a	1	WS	0.60	-		19	38	17	21	85	CI Intermediate Plasticity
RCEDS07	1	WS	0.50	-		20	53	22	31	84	CH High Plasticity
RCEDS08	1	WS	0.50	-		26	46	23	23	86	CI Intermediate Plasticity
RCEDS10	1	WS	0.30	-		15	34	16	18	81	CL Low Plasticity
RCEDS10	1	WS	0.70	-		23	41	20	21	75	CI Intermediate Plasticity
				-							
				-							
				-							
				-							
				-							
				-							
				-							
				-							

Symbols: NP : Non Plastic # : Liquid Limit and Plastic Limit Wet Sieved

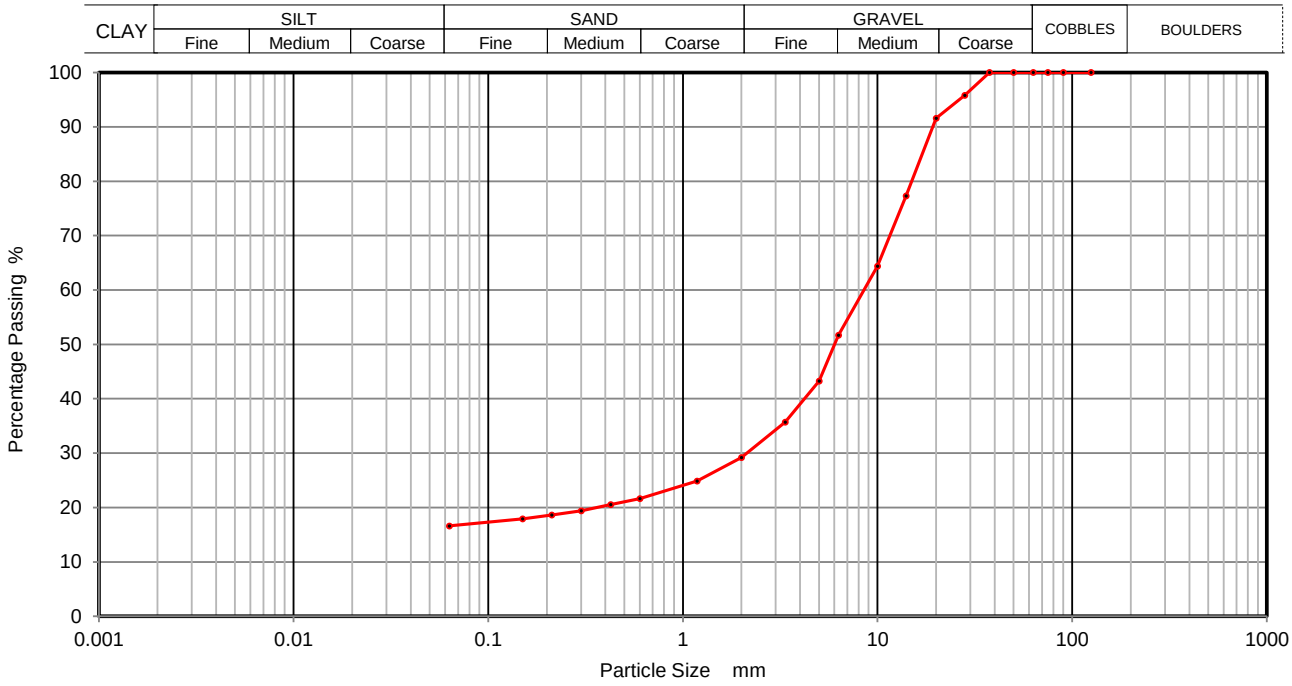
PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION
BS 5930:1999+A2:2010



Operators	Checked	19/12/2019	Wayne Honey (Administrative/Quality Assistant)
Daniel Bassett	Approved	19/12/2019	Paul Evans (Quality/Technical Manager)

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS01
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown silty sandy GRAVEL.	Depth Top	0.50
		Depth Base	1.00
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	96		
20	92		
14	77		
10	64		
6.3	52		
5	43		
3.35	36		
2	29		
1.18	25		
0.6	22		
0.425	21		
0.3	19		
0.212	19		
0.15	18		
0.063	17		

Sample Proportions	% dry mass
Cobbles	0
Gravel	71
Sand	12
Silt and Clay	17

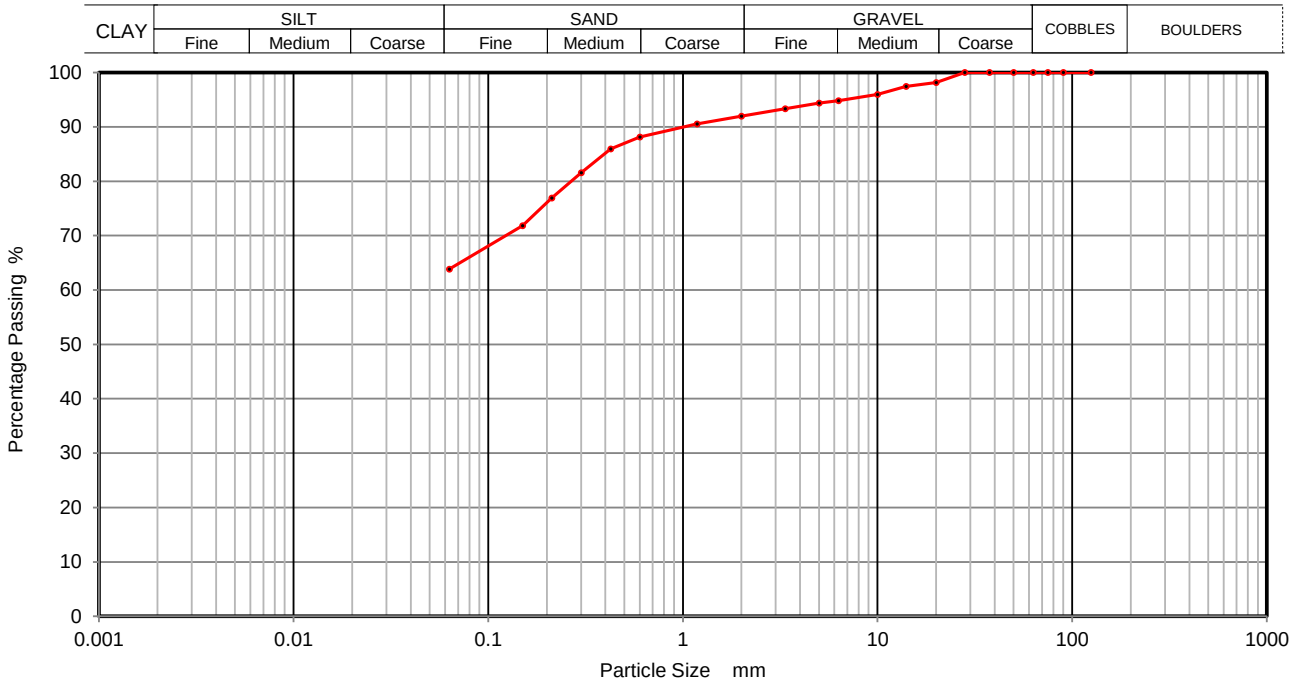
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS01
Site Name	A40 RCE	Sample No.	2
Soil Description	Brown gravelly sandy silty CLAY.	Depth Top	1.20
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	98		
14	97		
10	96		
6.3	95		
5	94		
3.35	93		
2	92		
1.18	91		
0.6	88		
0.425	86		
0.3	82		
0.212	77		
0.15	72		
0.063	64		

Sample Proportions	% dry mass
Cobbles	0
Gravel	8
Sand	28
Silt and Clay	64

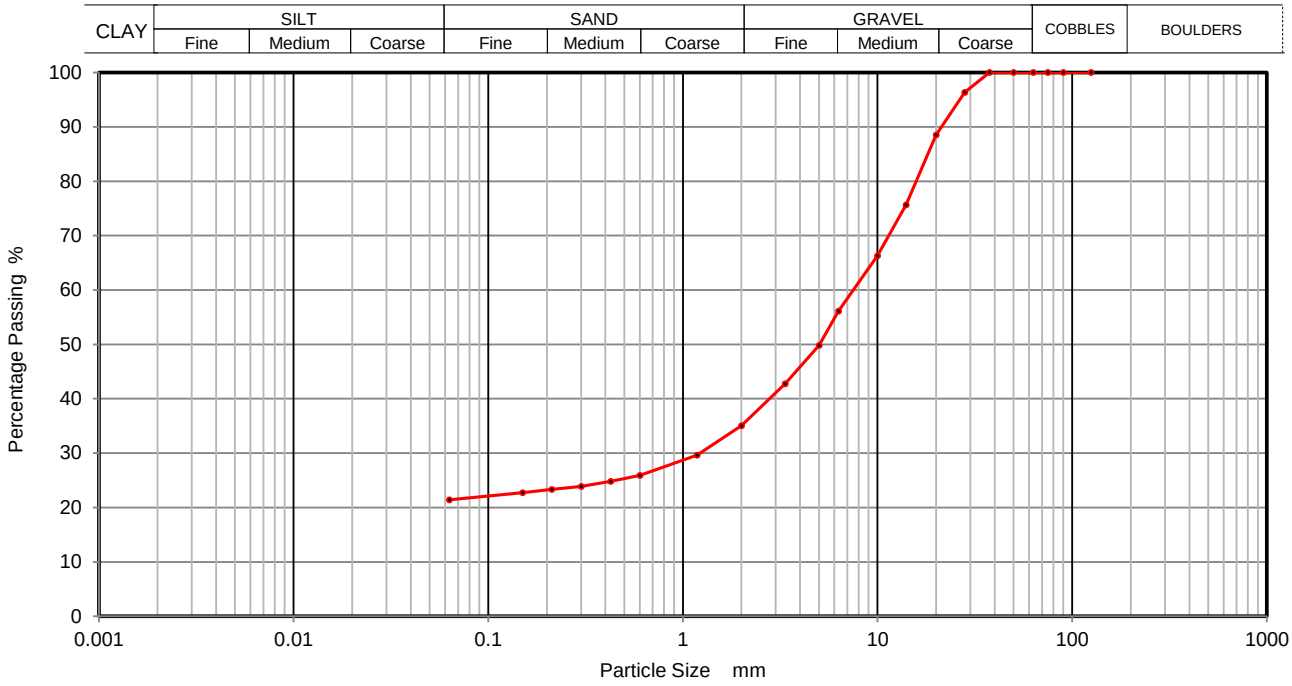
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS02
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown clayey silty sandy GRAVEL.	Depth Top	0.70
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	96		
20	89		
14	76		
10	66		
6.3	56		
5	50		
3.35	43		
2	35		
1.18	30		
0.6	26		
0.425	25		
0.3	24		
0.212	23		
0.15	23		
0.063	21		

Sample Proportions	% dry mass
Cobbles	0
Gravel	65
Sand	14
Silt and Clay	21

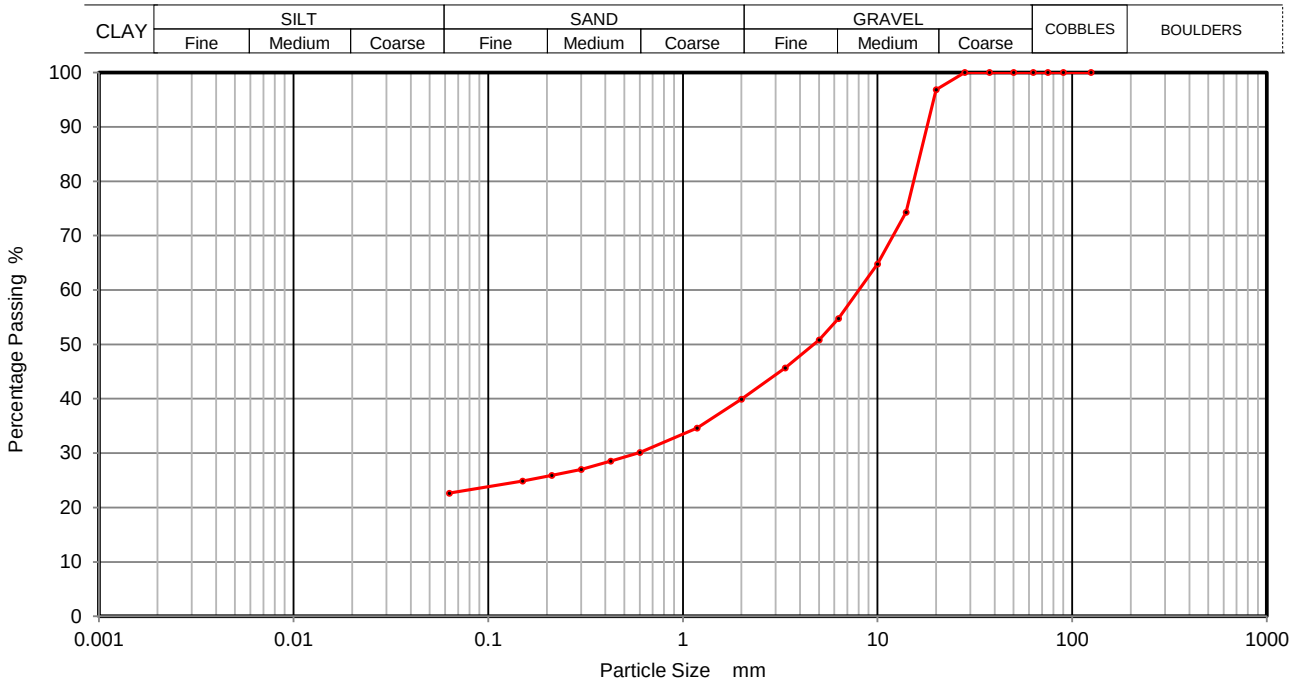
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS03
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown clayey silty sandy GRAVEL.	Depth Top	0.40
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	97		
14	74		
10	65		
6.3	55		
5	51		
3.35	46		
2	40		
1.18	35		
0.6	30		
0.425	29		
0.3	27		
0.212	26		
0.15	25		
0.063	23		

Sample Proportions	% dry mass
Cobbles	0
Gravel	60
Sand	17
Silt and Clay	23

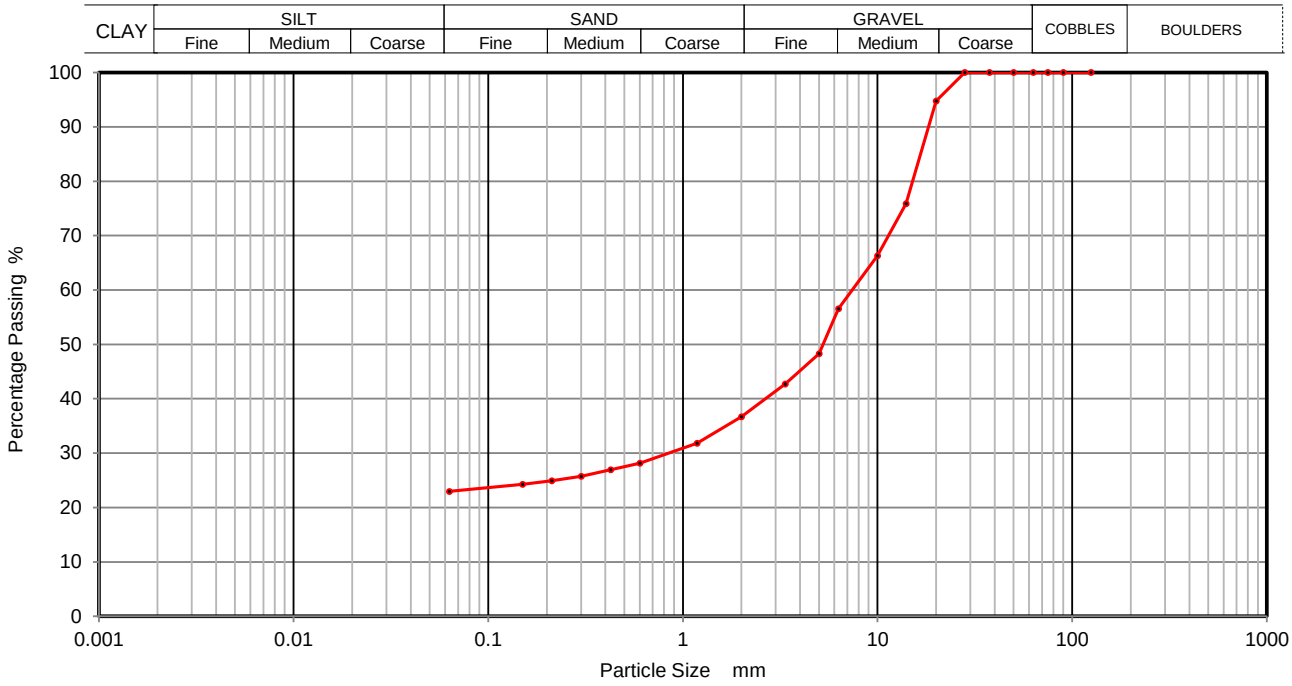
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS04
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown clayey silty sandy GRAVEL.	Depth Top	0.70
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	95		
14	76		
10	66		
6.3	57		
5	48		
3.35	43		
2	37		
1.18	32		
0.6	28		
0.425	27		
0.3	26		
0.212	25		
0.15	24		
0.063	23		

Sample Proportions	% dry mass
Cobbles	0
Gravel	63
Sand	14
Silt and Clay	23

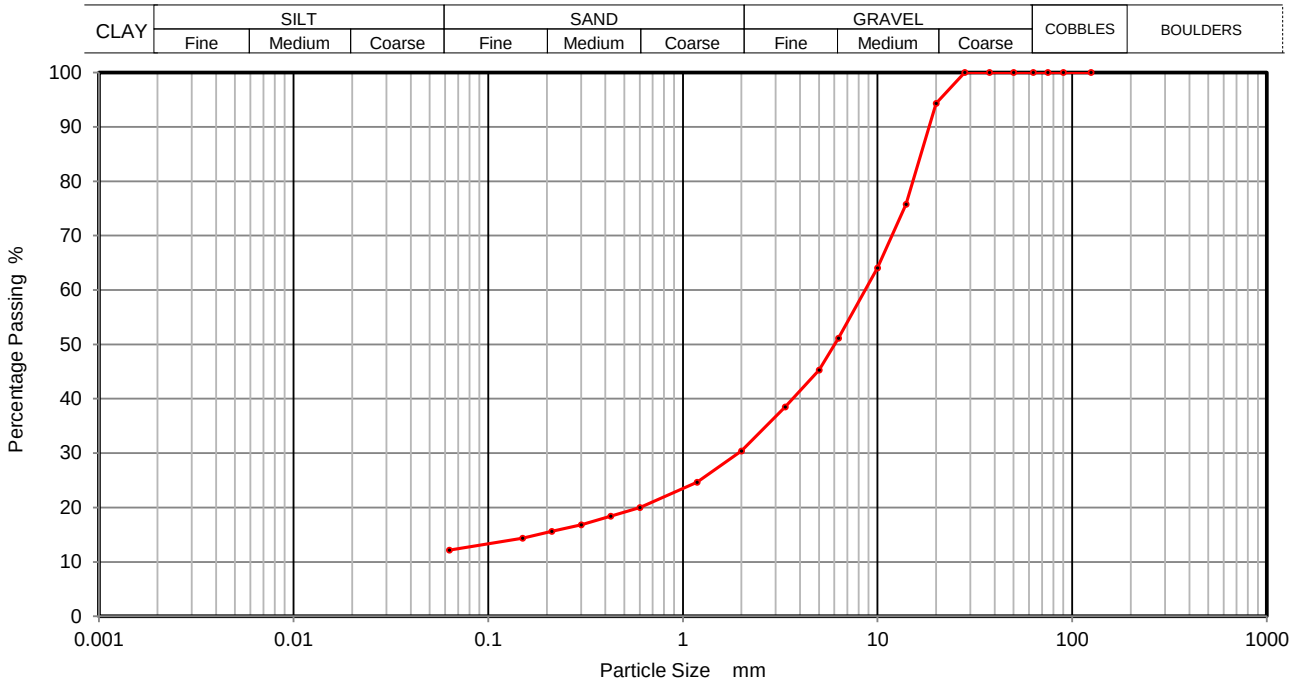
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS05
Site Name	A40 RCE	Sample No.	3
Soil Description	Brown clayey silty sandy GRAVEL.	Depth Top	1.00
		Depth Base	1.30
Date Tested	17/12/2019	Sample Type	D



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	94		
14	76		
10	64		
6.3	51		
5	45		
3.35	39		
2	30		
1.18	25		
0.6	20		
0.425	18		
0.3	17		
0.212	16		
0.15	14		
0.063	12		

Sample Proportions	% dry mass
Cobbles	0
Gravel	70
Sand	18
Silt and Clay	12

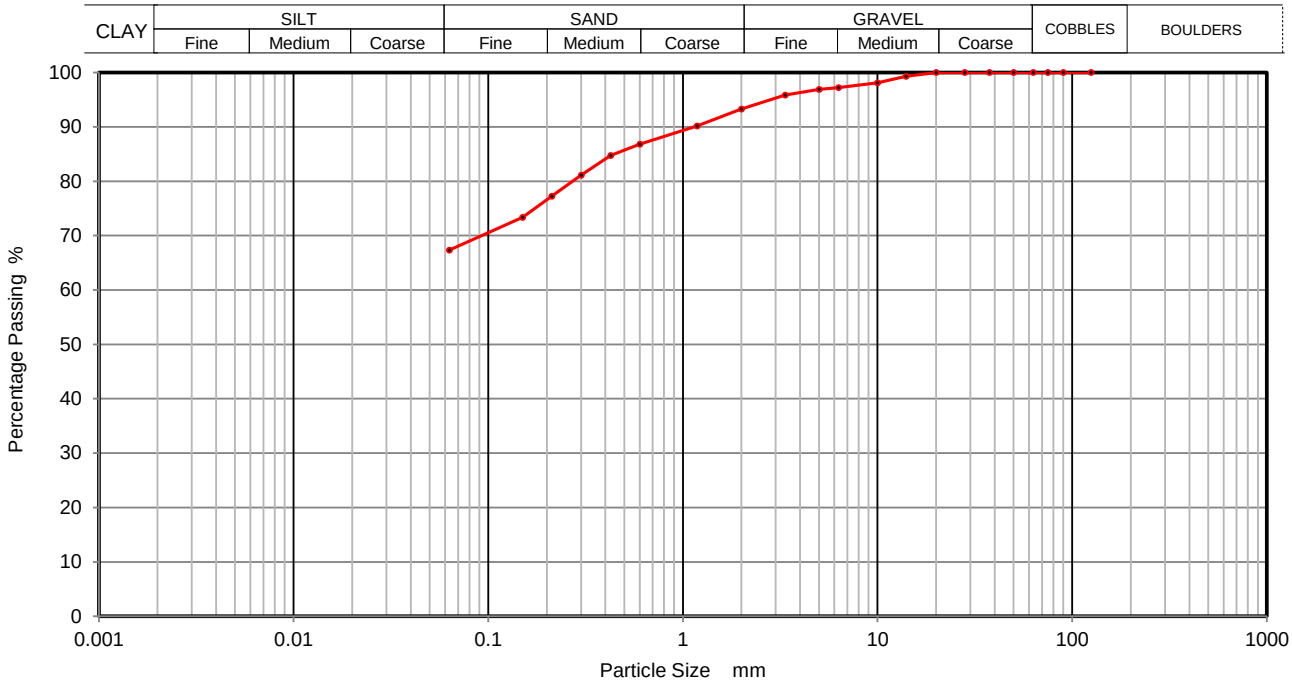
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS06a
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown gravelly sandy silty CLAY.	Depth Top	0.60
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	99		
10	98		
6.3	97		
5	97		
3.35	96		
2	93		
1.18	90		
0.6	87		
0.425	85		
0.3	81		
0.212	77		
0.15	73		
0.063	67		

Sample Proportions	% dry mass
Cobbles	0
Gravel	7
Sand	26
Silt and Clay	67

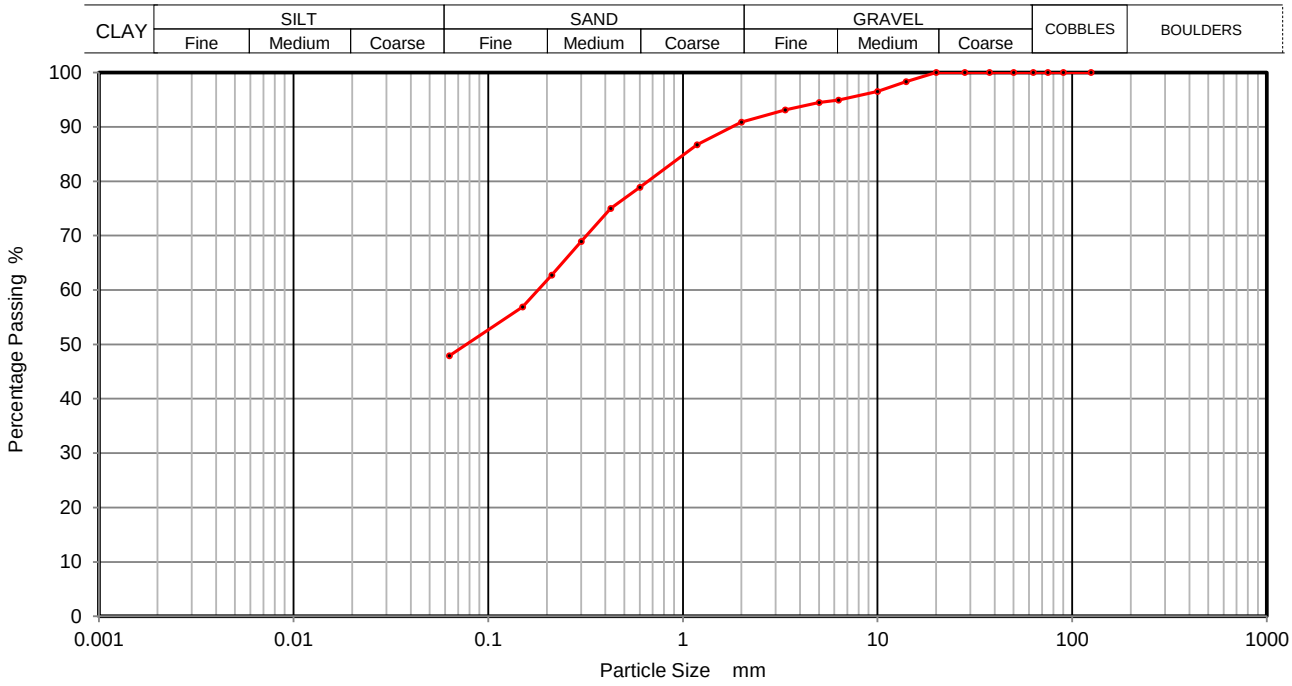
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	PARTICLE SIZE DISTRIBUTION BS 1377 Part 2:1990 Wet Sieve, Clause 9.2	Contract Number	46875
		Borehole/Pit No.	RCEDS10
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown gravelly sandy silty CLAY.	Depth Top	0.70
		Depth Base	
Date Tested	17/12/2019	Sample Type	WS



Sieving		Sedimentation	
Particle Size mm	% Passing	Particle Size mm	% Passing
125	100		
90	100		
75	100		
63	100		
50	100		
37.5	100		
28	100		
20	100		
14	98		
10	97		
6.3	95		
5	95		
3.35	93		
2	91		
1.18	87		
0.6	79		
0.425	75		
0.3	69		
0.212	63		
0.15	57		
0.063	48		

Sample Proportions	% dry mass
Cobbles	0
Gravel	9
Sand	43
Silt and Clay	48

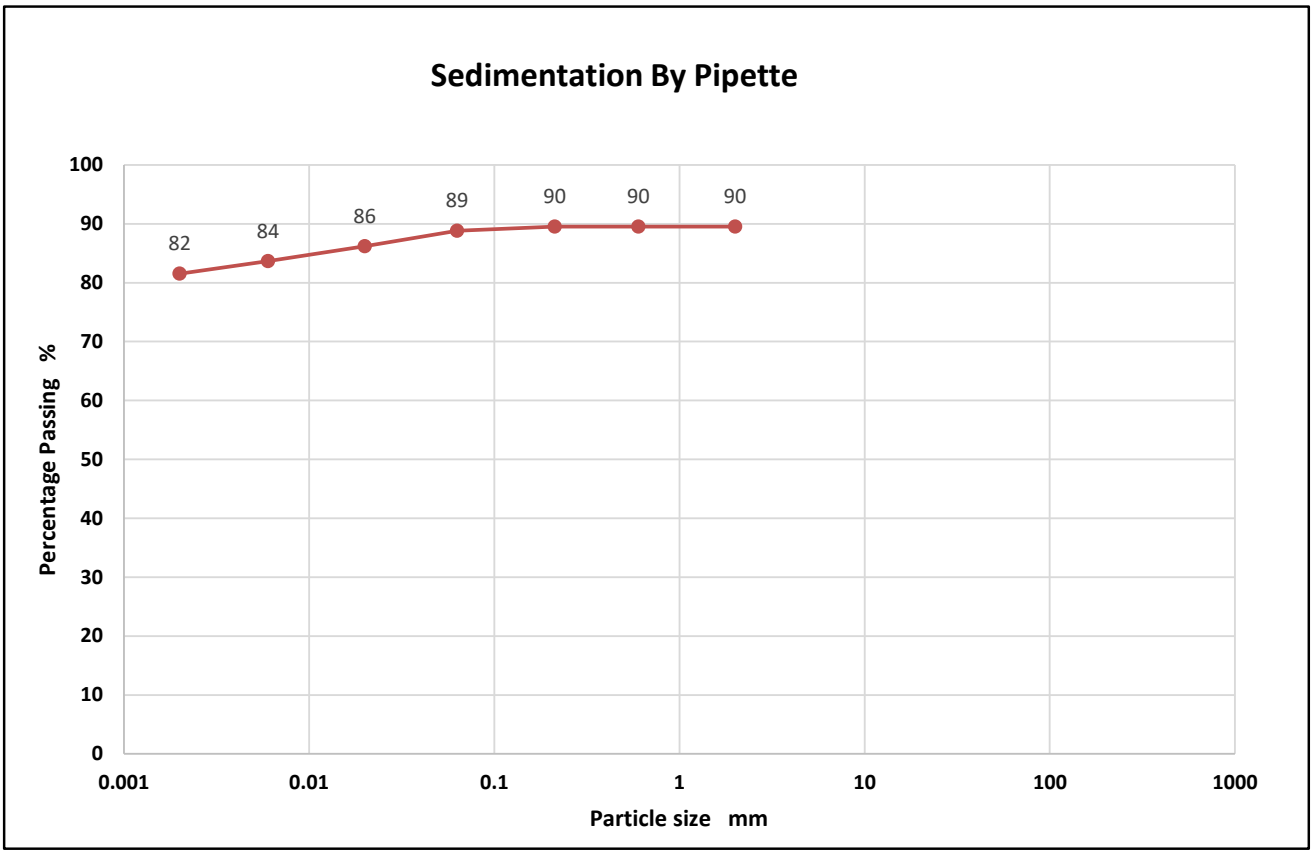
Remarks

Preparation and testing in accordance with BS1377 unless noted below

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO/MH	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS4
Site Name	A40 RCE	Sample No.	
Soil Description	Brown fine to medium gravelly CLAY	Depth Top	0.50
		Depth Base	
		Sample Type	DS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	90
0.60	90
0.212	90
0.063	89

Sedimentation Analysis

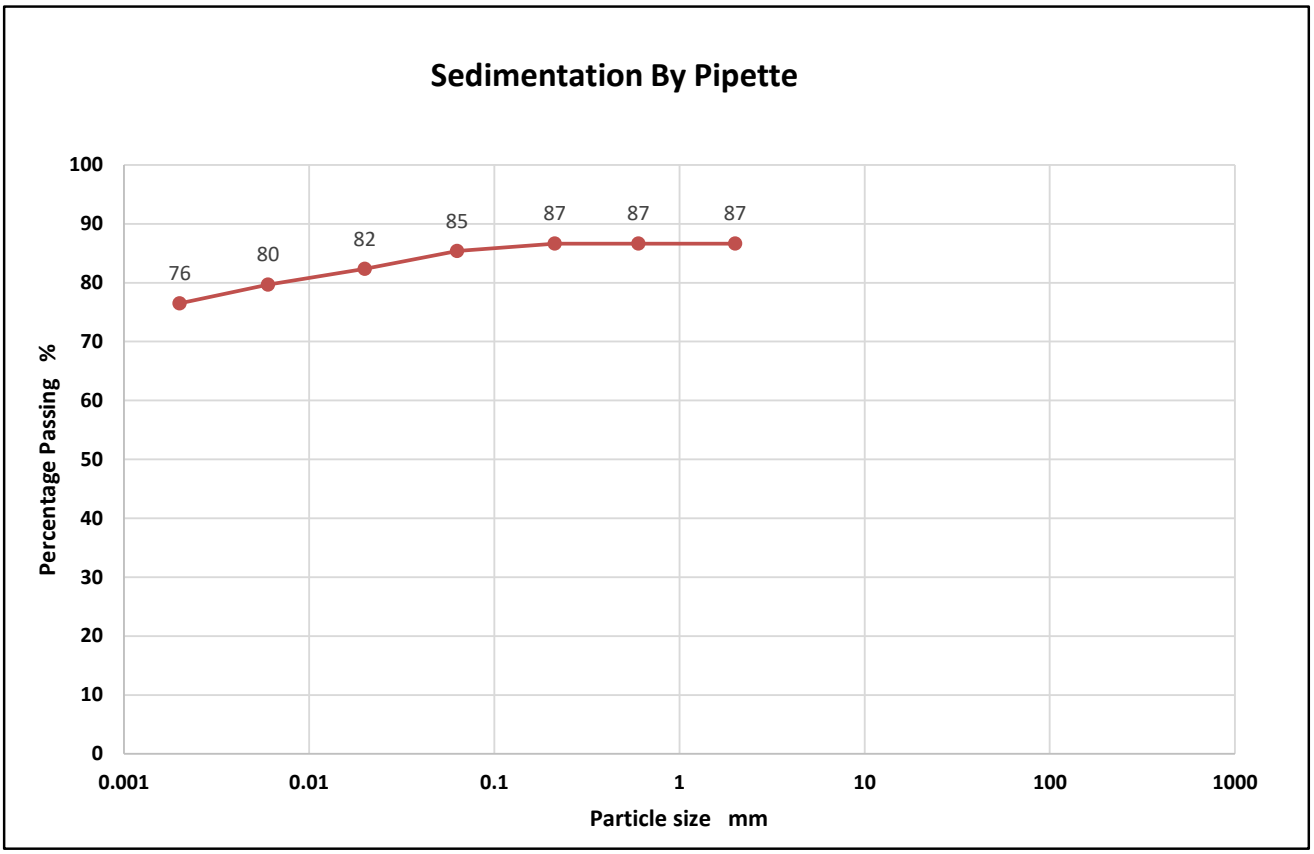
Particle Diameter	Percentage Passing
0.02	86
0.006	84
0.002	82

Soil Fraction	Total Percentage
Gravel	10
Sand	1
Silt	7
Clay	82

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS5
Site Name	A40 RCE	Sample No.	
Soil Description	Brown fine to medium gravelly CLAY	Depth Top	0.30
		Depth Base	0.70
		Sample Type	DS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	87
0.60	87
0.212	87
0.063	85

Sedimentation Analysis

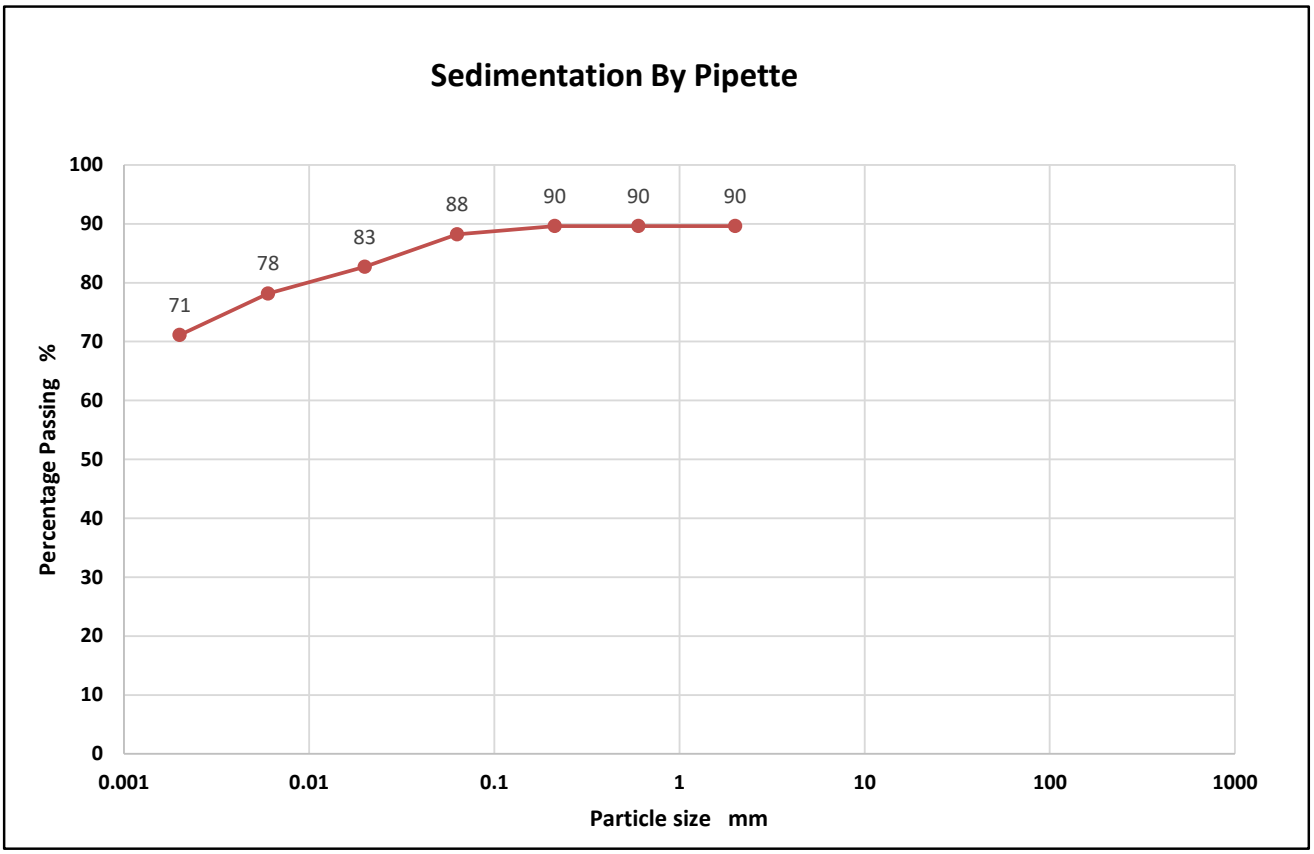
Particle Diameter	Percentage Passing
0.02	82
0.006	80
0.002	76

Soil Fraction	Total Percentage
Gravel	13
Sand	1
Silt	9
Clay	76

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS5
Site Name	A40 RCE	Sample No.	
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	1.60
		Depth Base	1.90
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	90
0.60	90
0.212	90
0.063	88

Sedimentation Analysis

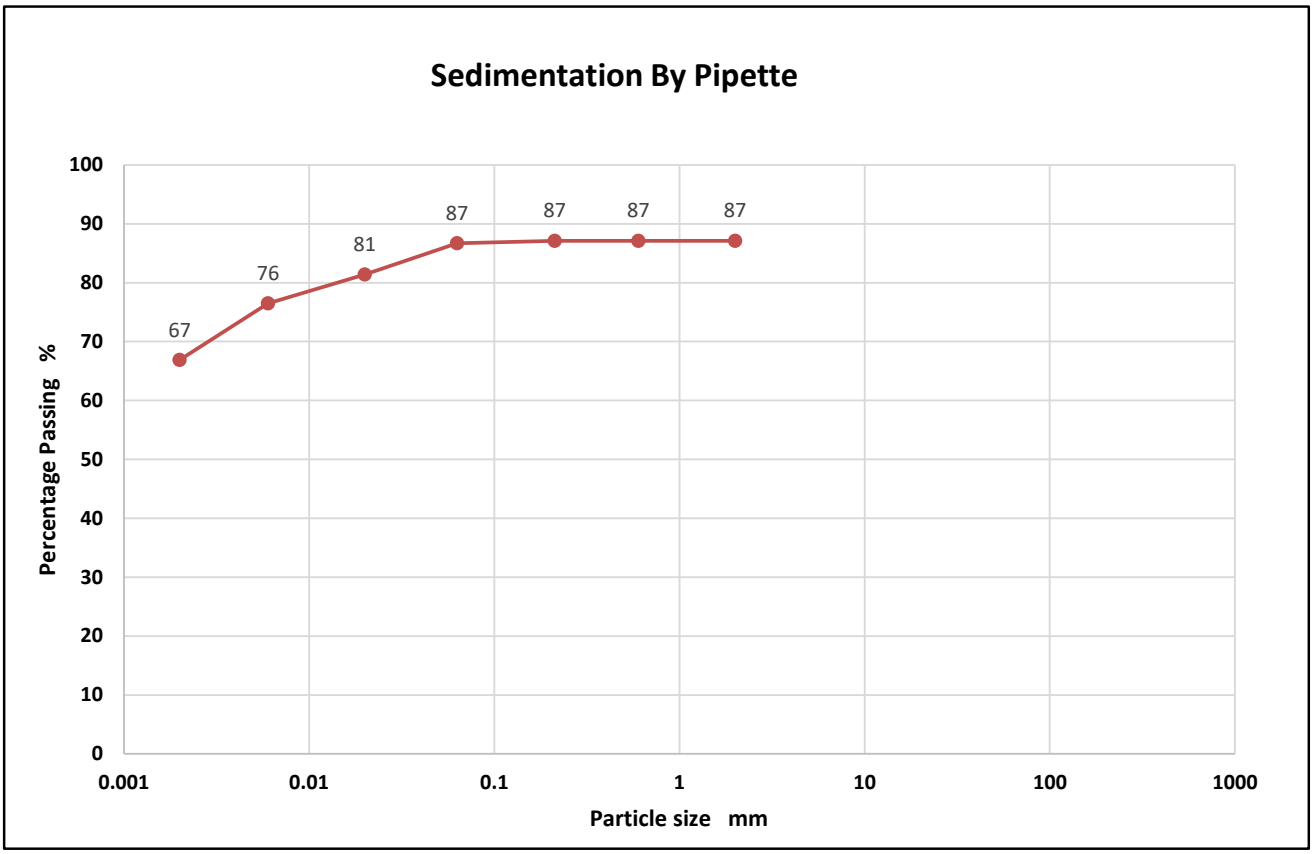
Particle Diameter	Percentage Passing
0.02	83
0.006	78
0.002	71

Soil Fraction	Total Percentage
Gravel	10
Sand	1
Silt	17
Clay	71

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS5
Site Name	A40 RCE	Sample No.	
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	2.00
		Depth Base	2.10
		Sample Type	D



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	87
0.60	87
0.212	87
0.063	87

Sedimentation Analysis

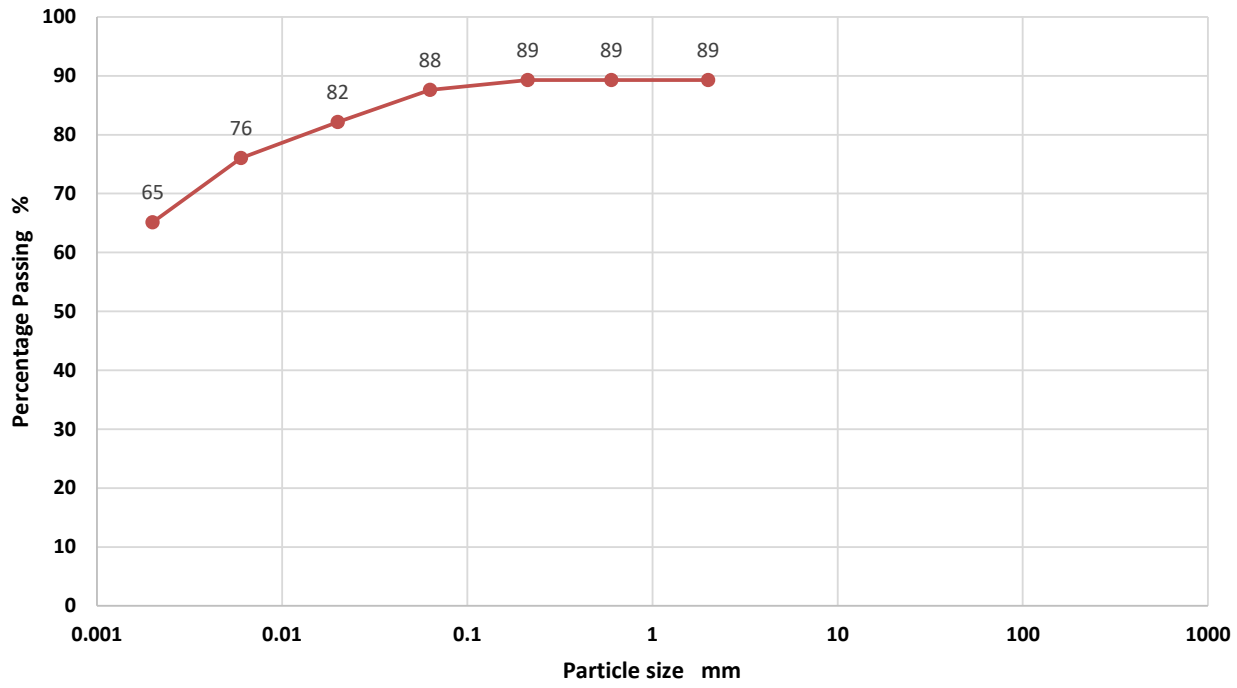
Particle Diameter	Percentage Passing
0.02	81
0.006	76
0.002	67

Soil Fraction	Total Percentage
Gravel	13
Sand	0
Silt	20
Clay	67

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS6a
Site Name	A40 RCE	Sample No.	
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	0.40
		Depth Base	
		Sample Type	WS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	89
0.60	89
0.212	89
0.063	88

Sedimentation Analysis

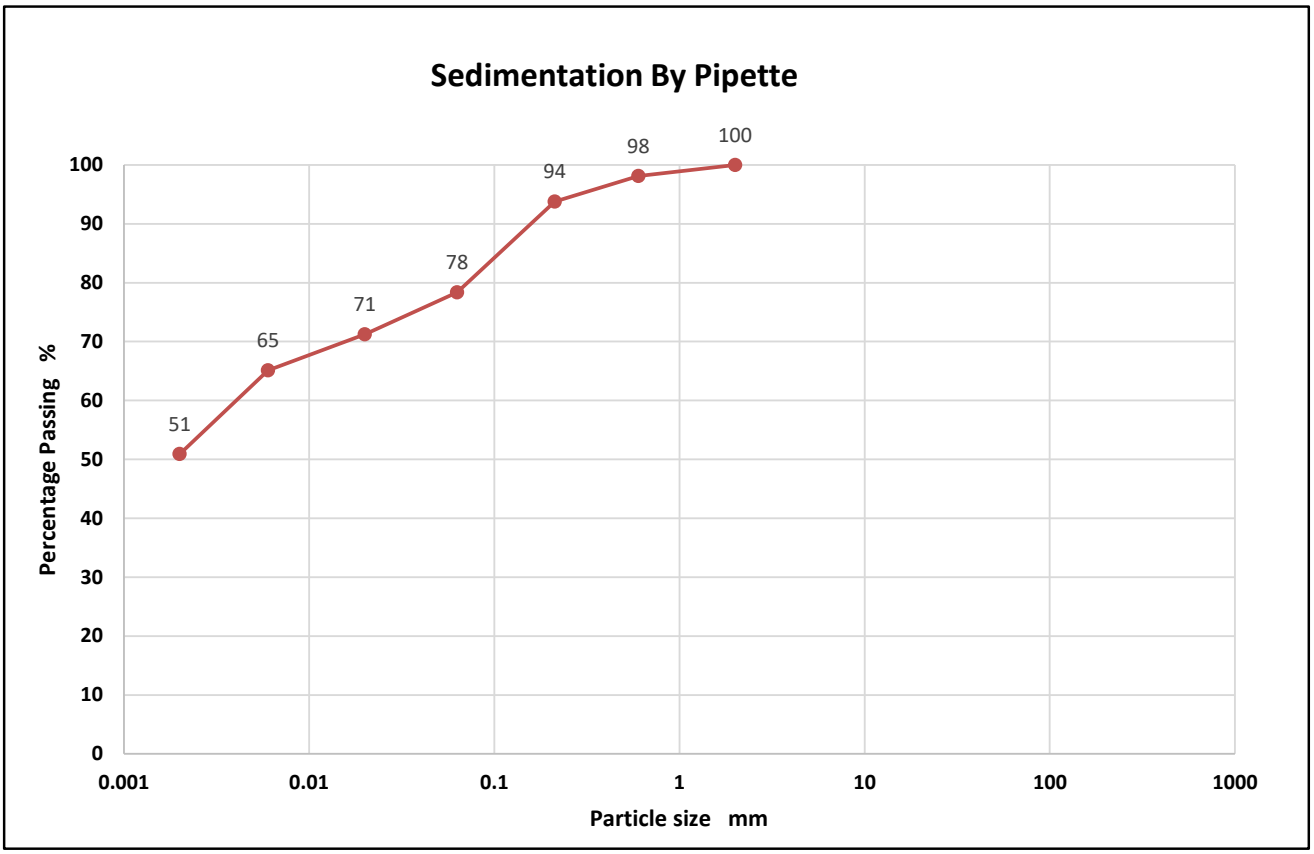
Particle Diameter	Percentage Passing
0.02	82
0.006	76
0.002	65

Soil Fraction	Total Percentage
Gravel	11
Sand	2
Silt	22
Clay	65

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS7
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown sandy, silty CLAY	Depth Top	0.50
		Depth Base	
		Sample Type	WS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	100
0.60	98
0.212	94
0.063	78

Sedimentation Analysis

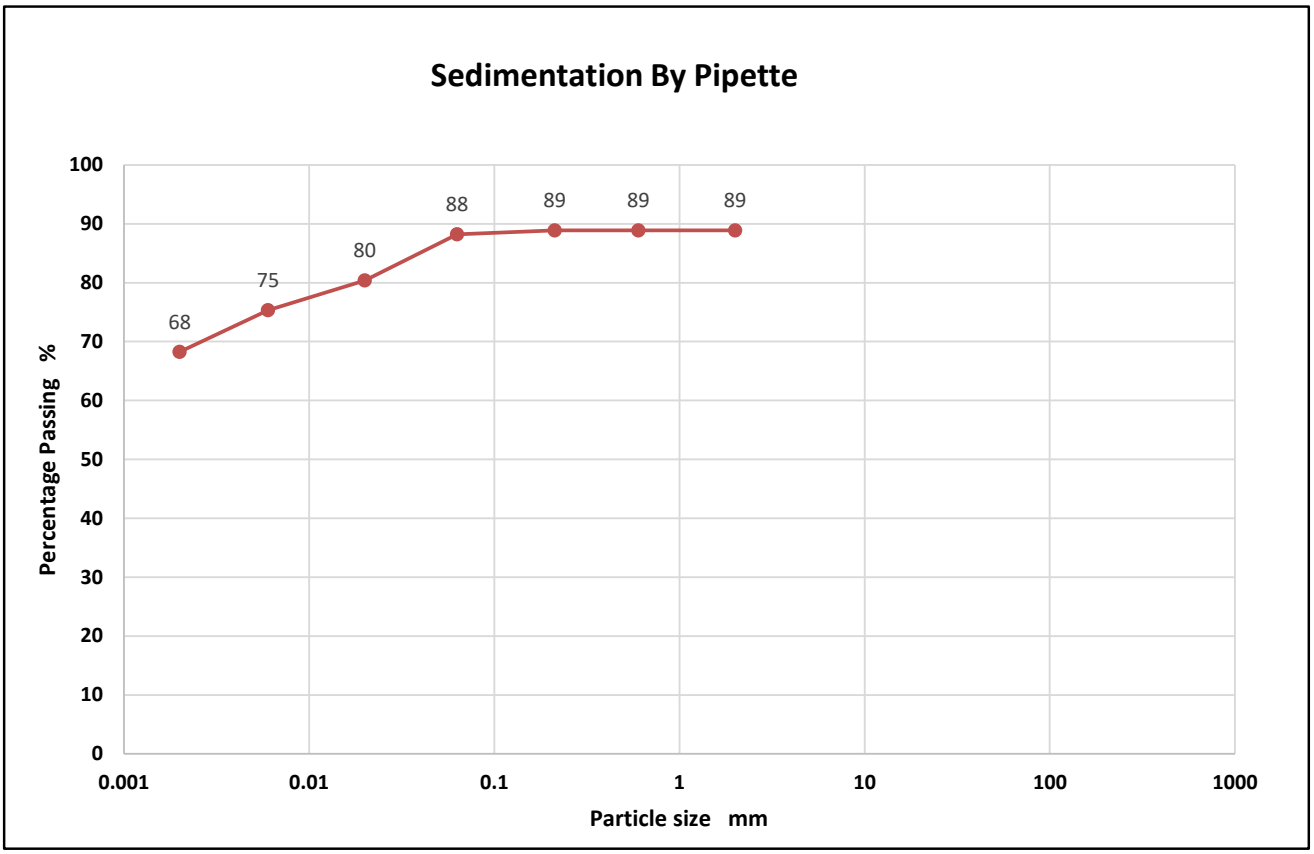
Particle Diameter	Percentage Passing
0.02	71
0.006	65
0.002	51

Soil Fraction	Total Percentage
Gravel	0
Sand	22
Silt	27
Clay	51

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS8
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	0.50
		Depth Base	
		Sample Type	WS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	89
0.60	89
0.212	89
0.063	88

Sedimentation Analysis

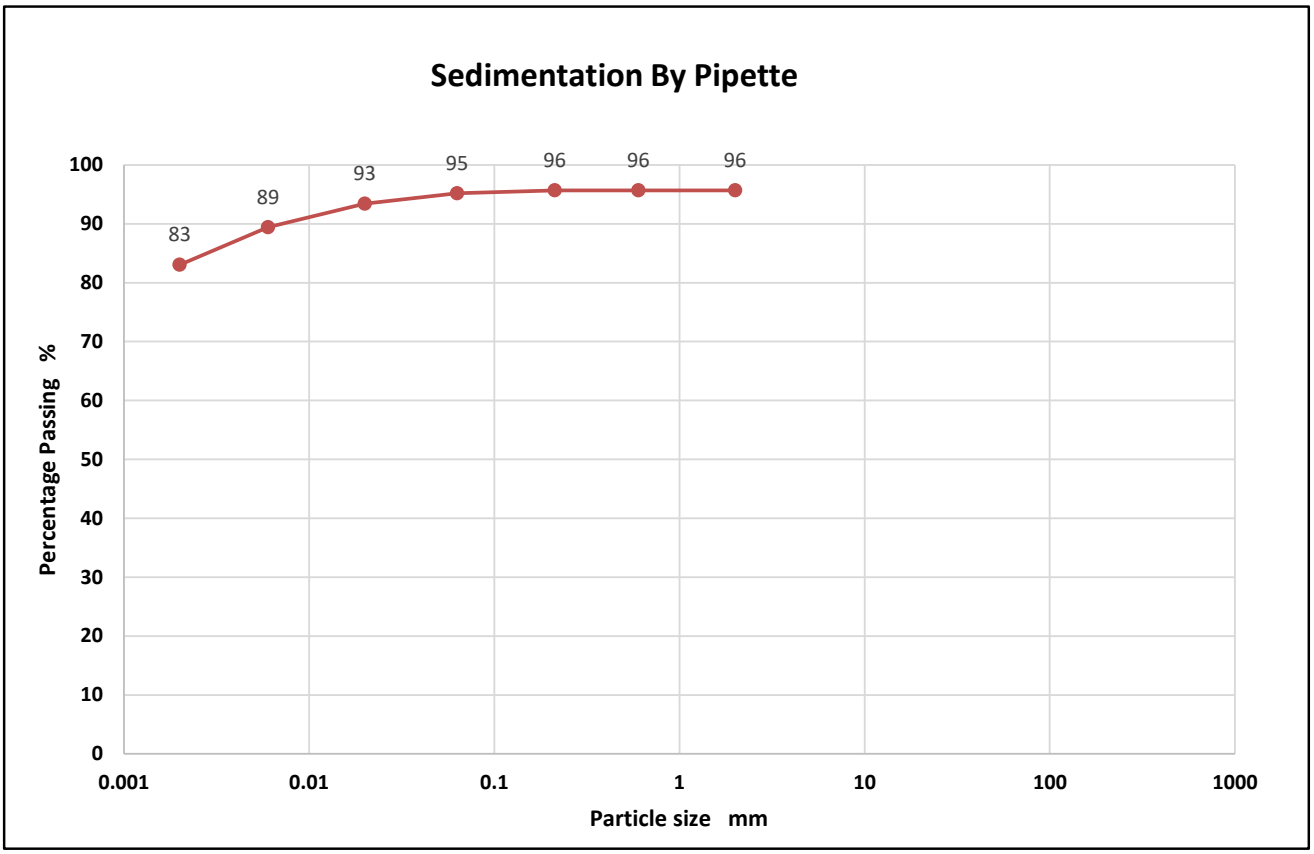
Particle Diameter	Percentage Passing
0.02	80
0.006	75
0.002	68

Soil Fraction	Total Percentage
Gravel	11
Sand	1
Silt	20
Clay	68

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Sedimentation By Pipette Analysis BS 1377 Part 2:1990 Clause 9.4	Contract Number	46875
		Borehole/Pit No.	RCE DS10
Site Name	A40 RCE	Sample No.	1
Soil Description	Brown fine to medium gravelly, silty CLAY	Depth Top	0.30
		Depth Base	
		Sample Type	WS



Top Sieve Analysis

BS Test Sieve	Percentage Passing
2.00	96
0.60	96
0.212	96
0.063	95

Sedimentation Analysis

Particle Diameter	Percentage Passing
0.02	93
0.006	89
0.002	83

Soil Fraction	Total Percentage
Gravel	4
Sand	0
Silt	12
Clay	83

Operators	Checked	18/12/2019	Wayne Honey	W. Honey
RO	Approved	19/12/2019	Paul Evans	D P Evans

UKAS TESTING
2788

GSTL	Certificate of Chemical Analysis (BRE BR 279)	Contract Number	46875
		Client Reference	Q0083
Client	Quantum	Date Received	
Site Name	A40 RCE	Date Started	06/12/2019
		Date Completed	19/12/2019
		No. of Samples	6

Hole Number	Sample Number	Sample Type	Depth (m)			Acid Soluble Sulphate	Aqueous Extract Sulphate	Chloride Content	pH Value	Total Sulphur	Magnesium	Nitrate
RCEDS01	2	WS	1.20	-		0.29	0.04		7.22	0.12		
RCEDS03	1	WS	0.40	-		0.31	0.03		7.05	0.13		
RCEDS05	3	B	0.30	-	0.70	0.25	0.03		7.36	0.10		
RCEDS06a	1	WS	0.60	-		0.31	0.04		7.41	0.13		
RCEDS07	1	WS	0.50	-		0.27	0.03		7.29	0.11		
RCEDS10	1	WS	0.70	-		0.33	0.04		6.87	0.14		
				-								
				-								
				-								
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Key	Reported As
Acid Soluble Sulphate	% SO_4
Aqueous Extract Sulphate	g/l SO_4
Chloride Content (Semi)	mg Cl/l
pH Value	@ 25°
Total Sulphur	% S
Magnesium	g/l SO_4
Nitrate	NO_3 mg/l

Remarks

NCP = No Chloride Present

Test Operator	Checked and Authorised by		Paul Evans	D P Evans
Darren Bourne	Date	19/12/2019		

APPENDIX VIII – CHEMICAL LABORATORY TEST RESULTS

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30239-1		
Initial Date of Issue:	18-Sep-2019		
Client	Quantum Geotechnic Ltd		
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40 RCE-LVP		
Quotation No.:	Q19-18166	**Date Received:**	09-Sep-2019
Order No.:		**Date Instructed:**	11-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	17-Sep-2019
Date Approved:	18-Sep-2019		

Approved By:

Details: Glynn Harvey, Laboratory Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 RCE-LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30239
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		885654
			Client Sample ID.:		1
			Sample Location:		RCEBH13
			Sample Type:		SOIL
			Top Depth (m):		0.30
			Date Sampled ($):		05-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	7.0
pH	U	2010		N/A	8.1
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	9.6
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	22
Copper	U	2450	mg/kg	0.50	16
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	33
Lead	U	2450	mg/kg	0.50	12
Selenium	U	2450	mg/kg	0.20	< 0.20
Zinc	U	2450	mg/kg	0.50	64
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50
Total Organic Carbon	U	2625	%	0.20	0.26
Total TPH >C6-C40	U	2670	mg/kg	10	< 10
Naphthalene	U	2800	mg/kg	0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30465-1		
Initial Date of Issue:	18-Sep-2019		
Client	Quantum Geotechnic Ltd		
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40 LVP/RCE		
Quotation No.:	Q19-18166	**Date Received:**	11-Sep-2019
Order No.:		**Date Instructed:**	11-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	17-Sep-2019
Date Approved:	18-Sep-2019		
Approved By:			
Details:	Glynn Harvey, Laboratory Manager		

Results - Leachate

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**		19-30465
Quotation No.: Q19-18166				**Chemtest Sample ID.:**		886769
Order No.:				Client Sample Ref.:		1
				Sample Location:		RCEBH14
				Sample Type:		SOIL
				Top Depth (m):		0.3
				Date Sampled ($):		06-Sep-2019
Determinand	**Accred.**	**SOP**	**Type**	**Units**	**LOD**	
pH	U	1010	2:1		N/A	4.6
Ammoniacal Nitrogen	U	1220	2:1	mg/l	0.050	0.21
Ammoniacal Nitrogen	U	1220	2:1	mg/kg	0.010	0.42
Cyanide (Total)	U	1300	2:1	mg/l	0.050	< 0.050

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30465
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		886769
Order No.:			Client Sample Ref.:		1
			Sample Location:		RCEBH14
			Sample Type:		SOIL
			Top Depth (m):		0.3
			Date Sampled ($):		06-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	11
pH	U	2010		N/A	7.4
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	8.9
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	14
Copper	U	2450	mg/kg	0.50	9.6
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	24
Lead	U	2450	mg/kg	0.50	12
Selenium	U	2450	mg/kg	0.20	0.47
Zinc	U	2450	mg/kg	0.50	55
Total Organic Carbon	U	2625	%	0.20	0.53
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10
Benzene	U	2760	µg/kg	1.0	< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30465
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		886769
Order No.:			Client Sample Ref.:		1
			Sample Location:		RCEBH14
			Sample Type:		SOIL
			Top Depth (m):		0.3
			Date Sampled ($):		06-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Results - 2 Stage WAC

Project: Q0083 A40 LVP/RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-30465								
Chemtest Sample ID:	886769								
Sample Ref:	1								
Sample ID:									
Sample Location:	RCEBH14								
Top Depth(m):	0.3								
Bottom Depth(m):									
Sampling Date ($):	06-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	< 0.0010		< 0.050		0.5	2	25
Barium	1450	U	0.0033		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	< 0.0010		< 0.050		0.5	10	70
Copper	1450	U	0.0021		< 0.050		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	0.0018		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	0.0031		< 0.010		0.1	0.5	7
Zinc	1450	U	0.0030		< 0.50		4	50	200
Chloride	1220	U	3.1		< 10		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.328
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.165

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Report Information

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D - Broken Container
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Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30473-1
Initial Date of Issue:	18-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 LVP/RCE

Quotation No.:	Q19-17528	**Date Received:**	11-Sep-2019
Order No.:		**Date Instructed:**	11-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	17-Sep-2019
Date Approved:	18-Sep-2019		

Approved By:

Details: Glynn Harvey, Laboratory Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30473
Quotation No.: Q19-17528			**Chemtest Sample ID.:**		886816
Order No.:			Client Sample Ref.:		3
			Sample Location:		RCEBH04
			Sample Type:		SOIL
			Top Depth (m):		1.0
			Date Sampled ($):		09-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	5.6
pH	U	2010		N/A	7.7
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	12
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	20
Copper	U	2450	mg/kg	0.50	13
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	28
Lead	U	2450	mg/kg	0.50	14
Selenium	U	2450	mg/kg	0.20	< 0.20
Zinc	U	2450	mg/kg	0.50	63
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50
Total Organic Carbon	U	2625	%	0.20	< 0.20
Total TPH >C6-C40	U	2670	mg/kg	10	< 10
Naphthalene	U	2800	mg/kg	0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

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If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30963-1
Initial Date of Issue:	23-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:	Q19-18181	**Date Received:**	13-Sep-2019
Order No.:		**Date Instructed:**	13-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	20-Sep-2019
Date Approved:	23-Sep-2019		

Approved By:

Details: Robert Monk, Technical Manager

Results - Leachate

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**		19-30963
Quotation No.: Q19-18181				**Chemtest Sample ID.:**		888873
Order No.:				Client Sample Ref.:		1
				Sample Location:		RCEBH07
				Sample Type:		SOIL
				Top Depth (m):		0.3
				Date Sampled ($):		11-Sep-2019
Determinand	**Accred.**	**SOP**	**Type**	**Units**	**LOD**	
pH	U	1010	2:1		N/A	8.9
Ammoniacal Nitrogen	U	1220	2:1	mg/l	0.050	0.065
Ammoniacal Nitrogen	U	1220	2:1	mg/kg	0.010	0.13
Cyanide (Total)	U	1300	2:1	mg/l	0.050	< 0.050

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30963
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		888873
Order No.:			Client Sample Ref.:		1
			Sample Location:		RCEBH07
			Sample Type:		SOIL
			Top Depth (m):		0.3
			Date Sampled ($):		11-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	20
pH	U	2010		N/A	6.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	8.1
Arsenic	U	2450	mg/kg	1.0	12
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	27
Copper	U	2450	mg/kg	0.50	15
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	27
Lead	U	2450	mg/kg	0.50	14
Selenium	U	2450	mg/kg	0.20	1.0
Zinc	U	2450	mg/kg	0.50	50
Total Organic Carbon	U	2625	%	0.20	0.81
Total TPH >C6-C40	U	2670	mg/kg	10	< 10
Naphthalene	U	2800	mg/kg	0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Results - 2 Stage WAC

Project: Q0083 A40 RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-30963								
Chemtest Sample ID:	888873								
Sample Ref:	1								
Sample ID:									
Sample Location:	RCEBH07								
Top Depth(m):	0.3								
Bottom Depth(m):									
Sampling Date ($):	11-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	< 0.0010		< 0.050		0.5	2	25
Barium	1450	U	0.0013		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	< 0.0010		< 0.050		0.5	10	70
Copper	1450	U	< 0.0010		< 0.050		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	< 0.0010		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	< 0.0010		< 0.010		0.1	0.5	7
Zinc	1450	U	0.0021		< 0.50		4	50	200
Chloride	1220	U	1.8		< 10		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.305
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.118

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

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customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30972-1		
Initial Date of Issue:	19-Sep-2019		
Client	Quantum Geotechnic Ltd		
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40 RCE		
Quotation No.:	Q19-18181	**Date Received:**	13-Sep-2019
Order No.:		**Date Instructed:**	13-Sep-2019
No. of Samples:	3		
Turnaround (Wkdays):	5	**Results Due:**	19-Sep-2019
Date Approved:	19-Sep-2019		
Approved By:			
Details:	Robert Monk, Technical Manager		

Results - Leachate

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**		19-30972	19-30972
Quotation No.: Q19-18181				**Chemtest Sample ID.:**		888914	888917
				Client Sample ID.:		3	1
				Sample Location:		RCE-TP19	RCE-BH06
				Sample Type:		SOIL	SOIL
				Top Depth (m):		0.7	0.3
				Date Sampled ($):		10-Sep-2019	10-Sep-2019
Determinand	**Accred.**	**SOP**	**Type**	**Units**	**LOD**		
pH	U	1010	2:1		N/A	7.9	7.8
Ammoniacal Nitrogen	U	1220	2:1	mg/l	0.050	0.13	0.051
Ammoniacal Nitrogen	U	1220	2:1	mg/kg	0.010	0.26	0.10
Cyanide (Total)	U	1300	2:1	mg/l	0.050	< 0.050	< 0.050

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30972	19-30972	19-30972
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		888914	888916	888917
			Client Sample ID.:		3	4	1
			Sample Location:		RCE-TP19	RCE-TP05	RCE-BH06
			Sample Type:		SOIL	SOIL	SOIL
			Top Depth (m):		0.7	1.0	0.3
			Date Sampled ($):		10-Sep-2019	10-Sep-2019	10-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Moisture	N	2030	%	0.020	8.7	9.4	19
pH	U	2010		N/A	7.8	7.8	7.1
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40	0.42
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	12	8.2	8.1
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	18	22	17
Copper	U	2450	mg/kg	0.50	15	25	6.2
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	36	42	13
Lead	U	2450	mg/kg	0.50	41	22	14
Selenium	U	2450	mg/kg	0.20	< 0.20	< 0.20	1.3
Zinc	U	2450	mg/kg	0.50	81	110	27
Chromium (Hexavalent)	N	2490	mg/kg	0.50		< 0.50	
Total Organic Carbon	U	2625	%	0.20	0.25	0.23	0.74
Total TPH >C6-C40	U	2670	mg/kg	10		< 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0		< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0		< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0		< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0		< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10		< 10
Benzene	U	2760	µg/kg	1.0	< 1.0		< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0		< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0		< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0		< 1.0

Chemtest
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Results - Soil

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-30972	19-30972	19-30972
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		888914	888916	888917
			Client Sample ID.:		3	4	1
			Sample Location:		RCE-TP19	RCE-TP05	RCE-BH06
			Sample Type:		SOIL	SOIL	SOIL
			Top Depth (m):		0.7	1.0	0.3
			Date Sampled ($):		10-Sep-2019	10-Sep-2019	10-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
o-Xylene	U	2760	µg/kg	1.0	< 1.0		< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30	< 0.30

Results - 2 Stage WAC

Project: Q0083 A40 RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-30972								
Chemtest Sample ID:	888914								
Sample Ref:									
Sample ID:	3								
Sample Location:	RCE-TP19								
Top Depth(m):	0.7								
Bottom Depth(m):									
Sampling Date ($):	10-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0018		< 0.050		0.5	2	25
Barium	1450	U	0.0033		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	< 0.0010		< 0.050		0.5	10	70
Copper	1450	U	0.0023		< 0.050		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	0.0017		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	0.0020		< 0.010		0.1	0.5	7
Zinc	1450	U	0.0087		< 0.50		4	50	200
Chloride	1220	U	3.9		< 10		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.333
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.105

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Results - 2 Stage WAC

Project: Q0083 A40 RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-30972								
Chemtest Sample ID:	888917								
Sample Ref:									
Sample ID:	1								
Sample Location:	RCE-BH06								
Top Depth(m):	0.3								
Bottom Depth(m):									
Sampling Date ($):	10-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	< 0.0010		< 0.050		0.5	2	25
Barium	1450	U	0.0036		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	< 0.0010		< 0.050		0.5	10	70
Copper	1450	U	0.0010		< 0.050		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	< 0.0010		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	< 0.0010		< 0.010		0.1	0.5	7
Zinc	1450	U	0.0027		< 0.50		4	50	200
Chloride	1220	U	8.1		16		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.309
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.135

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Test Methods

SOP	Title	Parameters included	Method summary
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-30973-1
Initial Date of Issue:	27-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:	Q19-18181	**Date Received:**	13-Sep-2019
Order No.:		**Date Instructed:**	13-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	7	**Results Due:**	23-Sep-2019
Date Approved:	26-Sep-2019		

Approved By:

Details: Robert Monk, Technical Manager

Results - 2 Stage WAC

Project: Q0083 A40 RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-30973								
Chemtest Sample ID:	888918								
Sample Ref:							**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Sample ID:	4								
Sample Location:	RCE-TP05								
Top Depth(m):	1.00								
Bottom Depth(m):									
Sampling Date ($):	10-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**						
Total Organic Carbon	2625	U	%			0.53	3	5	6
Loss on Ignition							--	--	10
Total BTEX	2760	U	mg/kg			< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				7.7	--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.5	2	25
Barium	1450	U	0.0025	0.0018	< 0.50	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.5	10	70
Copper	1450	U	0.0016	< 0.0010	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	0.0017	< 0.0010	< 0.010	< 0.010	0.5	10	50
Antimony	1450	U	< 0.0010	< 0.0010	< 0.010	< 0.010	0.06	0.7	5
Selenium	1450	U	0.0016	< 0.0010	< 0.010	< 0.010	0.1	0.5	7
Zinc	1450	U	0.0064	0.0025	< 0.50	< 0.50	4	50	200
Chloride	1220	U	5.9	2.1	12	24	800	15000	25000
Fluoride	1220	U	0.10	0.097	< 1.0	< 1.0	10	150	500
Sulphate	1220	U	22	68	44	640	1000	20000	50000
Total Dissolved Solids	1020	N	120	33	250	410	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	4.7	3.5	< 50	< 50	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	11

Leachate Test Information	
Leachant volume 1st extract/l	0.328
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.160

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Chemtest
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Test Methods

SOP	Title	Parameters included	Method summary
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2815	Polychlorinated Biphenyls (PCB) ICES7Congeners in Soils by GC-MS	ICES7 PCB congeners	Acetone/Hexane extraction / GC-MS
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

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<	"less than"
>	"greater than"
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Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
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D - Broken Container
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All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

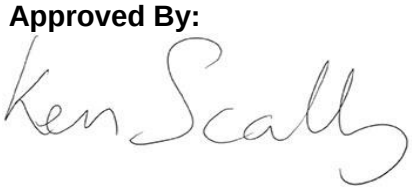
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-31262-1
Initial Date of Issue:	25-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Ty Berwig Bynea Llanelli Llanelli Camarthan SA14 9ST
Contact(s):	Hugh Woodroffe
Project	Q0083 A40-RCE-LUP

Quotation No.:		**Date Received:**	17-Sep-2019
Order No.:		**Date Instructed:**	17-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	23-Sep-2019
Date Approved:	25-Sep-2019		

Approved By:



Details: Ken Scally, Technical Director

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40-RCE-LUP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-31262
Quotation No.:			**Chemtest Sample ID.:**		890337
			Sample Location:		RCE-BH5
			Sample Type:		SOIL
			Top Depth (m):		0.30
			Date Sampled ($):		13-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	15
pH	U	2010		N/A	7.4
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.68
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	9.9
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	21
Copper	U	2450	mg/kg	0.50	15
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	21
Lead	U	2450	mg/kg	0.50	15
Selenium	U	2450	mg/kg	0.20	0.61
Zinc	U	2450	mg/kg	0.50	65
Total Organic Carbon	U	2625	%	0.20	0.60
Total TPH >C6-C40	U	2670	mg/kg	10	< 10
Naphthalene	U	2800	mg/kg	0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-31725-1
Initial Date of Issue:	30-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 LVP/RCE

Quotation No.:	Q19-18166	**Date Received:**	20-Sep-2019
Order No.:		**Date Instructed:**	24-Sep-2019
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	30-Sep-2019
Date Approved:	30-Sep-2019		

Approved By:

Details: Robert Monk, Technical Manager

Results - Leachate

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**		19-31725
Quotation No.: Q19-18166				**Chemtest Sample ID.:**		892846
Order No.:				Client Sample Ref.:		ES2
				Sample Location:		RCE-TP11
				Sample Type:		SOIL
				Top Depth (m):		0.30
				Date Sampled ($):		18-Sep-2019
Determinand	**Accred.**	**SOP**	**Type**	**Units**	**LOD**	
pH	U	1010	2:1		N/A	8.4
Ammoniacal Nitrogen	U	1220	2:1	mg/l	0.050	0.16
Ammoniacal Nitrogen	U	1220	2:1	mg/kg	0.010	0.30
Cyanide (Total)	U	1300	2:1	mg/l	0.050	< 0.050

Chemtest
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Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-31725	19-31725	19-31725	19-31725
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		892840	892841	892846	892848
Order No.:			Client Sample Ref.:		ES3	ES1	ES2	ES1
			Sample Location:		RCE-BH01	RCE-BH02	RCE-TP11	RCE-BH01
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		1.00	0.30	0.30	0.30
			Date Sampled ($):		17-Sep-2019	18-Sep-2019	18-Sep-2019	17-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Moisture	N	2030	%	0.020	16	11	27	25
pH	U	2010		N/A	7.2	7.0	5.6	6.2
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.50	< 0.40	< 0.40	0.52
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	15	9.5	19	16
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10	< 0.10	0.16
Chromium	U	2450	mg/kg	1.0	23	16	18	15
Copper	U	2450	mg/kg	0.50	23	24	7.7	13
Mercury	U	2450	mg/kg	0.10	0.15	< 0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	14	30	15	8.7
Lead	U	2450	mg/kg	0.50	47	15	11	23
Selenium	U	2450	mg/kg	0.20	0.76	0.25	0.43	0.55
Zinc	U	2450	mg/kg	0.50	110	81	27	36
Chromium (Hexavalent)	N	2490	mg/kg	0.50				< 0.50
Total Organic Carbon	U	2625	%	0.20	0.30	0.21	< 0.20	1.1
Total TPH >C6-C40	U	2670	mg/kg	10	< 10			
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		< 10	< 10	< 10
Benzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0
Toluene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**	19-31725	19-31725	19-31725	19-31725
Quotation No.: Q19-18166				**Chemtest Sample ID.:**	892840	892841	892846	892848
Order No.:				Client Sample Ref.:	ES3	ES1	ES2	ES1
				Sample Location:	RCE-BH01	RCE-BH02	RCE-TP11	RCE-BH01
				Sample Type:	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	1.00	0.30	0.30	0.30
				Date Sampled ($):	17-Sep-2019	18-Sep-2019	18-Sep-2019	17-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
o-Xylene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30	< 0.30	< 0.30

Results - 2 Stage WAC

Project: Q0083 A40 LVP/RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-31725								
Chemtest Sample ID:	892846								
Sample Ref:	ES2								
Sample ID:									
Sample Location:	RCE-TP11								
Top Depth(m):	0.30								
Bottom Depth(m):									
Sampling Date ($):	18-Sep-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0052		< 0.050		0.5	2	25
Barium	1450	U	0.0035		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	0.0037		< 0.050		0.5	10	70
Copper	1450	U	0.047		0.089		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	0.0016		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	0.0011		< 0.010		0.1	0.5	7
Zinc	1450	U	0.0082		< 0.50		4	50	200
Chloride	1220	U	3.6		< 10		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.287
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.200

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Test Methods

SOP	Title	Parameters included	Method summary
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Report Information

Key

U	UKAS accredited
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N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

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If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-31815-1
Initial Date of Issue:	30-Sep-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 LVP/RCE

Quotation No.:	Q19-18166	**Date Received:**	23-Sep-2019
Order No.:		**Date Instructed:**	24-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	5	**Results Due:**	30-Sep-2019
Date Approved:	30-Sep-2019		

Approved By:

Details: Robert Monk, Technical Manager

Chemtest
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Results - Soil

Project: Q0083 A40 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-31815
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		893282
Order No.:			Client Sample Ref.:		ES1
			Sample Location:		RCEBH08
			Sample Type:		SOIL
			Top Depth (m):		0.30
			Date Sampled ($):		19-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**	
Moisture	N	2030	%	0.020	26
pH	U	2010		N/A	5.5
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	9.0
Cadmium	U	2450	mg/kg	0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	21
Copper	U	2450	mg/kg	0.50	5.3
Mercury	U	2450	mg/kg	0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	20
Lead	U	2450	mg/kg	0.50	19
Selenium	U	2450	mg/kg	0.20	0.24
Zinc	U	2450	mg/kg	0.50	29
Total Organic Carbon	U	2625	%	0.20	1.3
Total TPH >C6-C40	U	2670	mg/kg	10	< 10
Naphthalene	U	2800	mg/kg	0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
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T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

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D - Broken Container
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Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
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Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

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Final Report

Report No.:	19-31971-1
Initial Date of Issue:	02-Oct-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:	Q19-18166	**Date Received:**	24-Sep-2019
Order No.:		**Date Instructed:**	24-Sep-2019
No. of Samples:	1		
Turnaround (Wkdays):	7	**Results Due:**	02-Oct-2019
Date Approved:	02-Oct-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

Results - 2 Stage WAC

Project: Q0083 A40 RCE

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-31971								
Chemtest Sample ID:	893985								
Sample Ref:									
Sample ID:	ES1								
Sample Location:	RCE-BH01								
Top Depth(m):	0.30								
Bottom Depth(m):									
Sampling Date ($):									
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon	2625	U	%			[A] 0.38	3	5	6
Loss on Ignition							--	--	10
Total BTEX	2760	U	mg/kg			[A] < 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg			< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg			[A] < 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg			< 2.0	100	--	--
pH	2010	U				7.2	--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0015	< 0.0010	< 0.050	< 0.050	0.5	2	25
Barium	1450	U	0.0023	0.0018	< 0.50	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.00010	< 0.010	< 0.010	0.04	1	5
Chromium	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.5	10	70
Copper	1450	U	0.0023	0.0015	< 0.050	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.00050	< 0.0010	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.0010	< 0.0010	< 0.050	< 0.050	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.0010	< 0.050	< 0.050	0.4	10	40
Lead	1450	U	0.0026	< 0.0010	< 0.010	< 0.010	0.5	10	50
Antimony	1450	U	0.0011	< 0.0010	< 0.010	< 0.010	0.06	0.7	5
Selenium	1450	U	0.0017	< 0.0010	< 0.010	< 0.010	0.1	0.5	7
Zinc	1450	U	0.0067	0.0058	< 0.50	< 0.50	4	50	200
Chloride	1220	U	1.9	1.8	< 10	18	800	15000	25000
Fluoride	1220	U	0.097	0.12	< 1.0	1.2	10	150	500
Sulphate	1220	U	11	2.2	22	27	1000	20000	50000
Total Dissolved Solids	1020	N	35	21	68	220	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.030	< 0.30	< 0.50	1	-	-
Dissolved Organic Carbon	1610	U	24	20	< 50	200	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.175
Moisture (%)	16

Leachate Test Information	
Leachant volume 1st extract/l	0.318
Leachant volume 2nd extract/l	1.400
Eluant recovered from 1st extract/l	0.101

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
893985		ES1	RCE-BH01		A	Amber Glass 250ml
893985		ES1	RCE-BH01		A	Amber Glass 60ml
893985		ES1	RCE-BH01		A	Plastic Tub 500g

Test Methods

SOP	Title	Parameters included	Method summary
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID (GC-FID detection is non-selective and can be subject to interference from co-eluting compounds)
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2815	Polychlorinated Biphenyls (PCB) ICES7Congeners in Soils by GC-MS	ICES7 PCB congeners	Acetone/Hexane extraction / GC-MS
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

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Final Report

Report No.:	19-32293-1
Initial Date of Issue:	02-Oct-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	A40 RCE

Quotation No.:	Q19-18166	**Date Received:**	26-Sep-2019
Order No.:		**Date Instructed:**	26-Sep-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	02-Oct-2019
Date Approved:	02-Oct-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32293	19-32293
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		895568	895569
			Client Sample ID.:		ES4	ES2
			Sample Location:		RCETP02	RCETP03
			Sample Type:		SOIL	SOIL
			Top Depth (m):		1.00	0.30
			Date Sampled ($):		20-Sep-2019	23-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	9.0	22
pH	U	2010		N/A	7.8	7.0
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	11	11
Cadmium	U	2450	mg/kg	0.10	< 0.10	0.18
Chromium	U	2450	mg/kg	1.0	6.1	10
Copper	U	2450	mg/kg	0.50	4.5	9.1
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	2.1	5.3
Lead	U	2450	mg/kg	0.50	10	21
Selenium	U	2450	mg/kg	0.20	< 0.20	0.37
Zinc	U	2450	mg/kg	0.50	3.9	23
Total Organic Carbon	U	2625	%	0.20	< 0.20	3.4
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10	< 10
Benzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	

Chemtest
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Results - Soil

Project: A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**	19-32293	19-32293
Quotation No.: Q19-18166			**Chemtest Sample ID.:**	895568	895569
			Client Sample ID.:	ES4	ES2
			Sample Location:	RCETP02	RCETP03
			Sample Type:	SOIL	SOIL
			Top Depth (m):	1.00	0.30
			Date Sampled ($):	20-Sep-2019	23-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	
Fluorene	U	2800	mg/kg	0.10	< 0.10	
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	
Anthracene	U	2800	mg/kg	0.10	< 0.10	
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	
Pyrene	U	2800	mg/kg	0.10	< 0.10	
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	
Chrysene	U	2800	mg/kg	0.10	< 0.10	
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

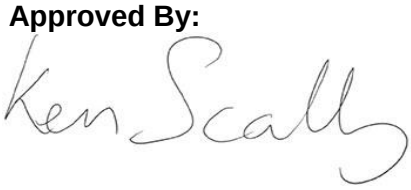
UKAS TESTING
2183

Final Report

Report No.:	19-32788-1
Initial Date of Issue:	28-Nov-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:	Q19-18166	**Date Received:**	01-Oct-2019
Order No.:		**Date Instructed:**	18-Nov-2019
No. of Samples:	3		
Turnaround (Wkdays):	5	**Results Due:**	22-Nov-2019
Date Approved:	28-Nov-2019		

Approved By:



Details: Ken Scally, Technical Director

Chemtest
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Results - Soil

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32788	19-32788
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		897901	897902
Order No.:			Client Sample Ref.:		3	1
			Sample Location:		RCETP15	RCETP13
			Sample Type:		SOIL	SOIL
			Top Depth (m):		1.0	0.3
			Date Sampled ($):		26-Sep-2019	26-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	11	8.6
pH	U	2010		N/A	6.8	6.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	18	15
Cadmium	U	2450	mg/kg	0.10	< 0.10	0.12
Chromium	U	2450	mg/kg	1.0	27	22
Copper	U	2450	mg/kg	0.50	16	10
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	31	19
Lead	U	2450	mg/kg	0.50	21	27
Selenium	U	2450	mg/kg	0.20	0.40	0.67
Zinc	U	2450	mg/kg	0.50	68	45
Total Organic Carbon	U	2625	%	0.20	0.90	2.1
Total TPH >C6-C40	U	2670	mg/kg	10	< 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		< 10
Benzene	U	2760	µg/kg	1.0		< 1.0
Toluene	U	2760	µg/kg	1.0		< 1.0
Ethylbenzene	U	2760	µg/kg	1.0		< 1.0
m & p-Xylene	U	2760	µg/kg	1.0		< 1.0
o-Xylene	U	2760	µg/kg	1.0		< 1.0

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32788	19-32788
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		897901	897902
Order No.:			Client Sample Ref.:		3	1
			Sample Location:		RCETP15	RCETP13
			Sample Type:		SOIL	SOIL
			Top Depth (m):		1.0	0.3
			Date Sampled ($):		26-Sep-2019	26-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Chemtest
The right chemistry to deliver results

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

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U/S	Unsuitable Sample
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>	"greater than"
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The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
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Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-32803-1
Initial Date of Issue:	09-Oct-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A14 LVP/RCE

Quotation No.:	Q19-18181	**Date Received:**	01-Oct-2019
Order No.:		**Date Instructed:**	02-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	08-Oct-2019
Date Approved:	09-Oct-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

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Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32803	19-32803
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		897990	897993
			Sample Location:		RCETP06	RCETP07
			Sample Type:		SOIL	SOIL
			Top Depth (m):		1.0	0.3
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	7.1	18
pH	U	2010		N/A	[A] 7.3	[A] 6.5
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	[A] < 0.50	[A] < 0.50
Arsenic	U	2450	mg/kg	1.0	15	13
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	24	23
Copper	U	2450	mg/kg	0.50	14	10
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	32	22
Lead	U	2450	mg/kg	0.50	15	22
Selenium	U	2450	mg/kg	0.20	< 0.20	0.72
Zinc	U	2450	mg/kg	0.50	74	59
Total Organic Carbon	U	2625	%	0.20	[A] 0.28	[A] 1.3
Total TPH >C6-C40	U	2670	mg/kg	10	[A] < 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		[A] < 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		[A] < 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		[A] < 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		[A] < 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		[A] < 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		[A] < 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		[A] < 10
Benzene	U	2760	µg/kg	1.0		[A] < 1.0
Toluene	U	2760	µg/kg	1.0		[A] 1.5
Ethylbenzene	U	2760	µg/kg	1.0		[A] < 1.0
m & p-Xylene	U	2760	µg/kg	1.0		[A] < 1.0
o-Xylene	U	2760	µg/kg	1.0		[A] < 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32803	19-32803
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		897990	897993
			Sample Location:		RCETP06	RCETP07
			Sample Type:		SOIL	SOIL
			Top Depth (m):		1.0	0.3
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
897990			RCETP06		A	Amber Glass 250ml
897990			RCETP06		A	Amber Glass 60ml
897990			RCETP06		A	Plastic Tub 500g
897993			RCETP07		A	Amber Glass 250ml
897993			RCETP07		A	Amber Glass 60ml
897993			RCETP07		A	Plastic Tub 500g

Chemtest
The right chemistry to deliver results

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

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The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-33216-1
Initial Date of Issue:	16-Oct-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE/LVP

Quotation No.:	Q19-18166	**Date Received:**	03-Oct-2019
Order No.:		**Date Instructed:**	10-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	16-Oct-2019
Date Approved:	16-Oct-2019		

Approved By:

Details: Robert Monk, Technical Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-33216	19-33216
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		899911	899913
			Client Sample ID.:		ES2	ES2
			Sample Location:		RCETP10	RCETP09
			Sample Type:		SOIL	SOIL
			Top Depth (m):		0.30	0.30
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	21	16
pH	U	2010		N/A	[A] 5.3	[A] 7.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.58	0.41
Cyanide (Total)	U	2300	mg/kg	0.50	[A] < 0.50	[A] < 0.50
Arsenic	U	2450	mg/kg	1.0	6.9	11
Cadmium	U	2450	mg/kg	0.10	0.11	0.13
Chromium	U	2450	mg/kg	1.0	8.5	21
Copper	U	2450	mg/kg	0.50	5.4	14
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	7.4	21
Lead	U	2450	mg/kg	0.50	11	30
Selenium	U	2450	mg/kg	0.20	0.95	0.74
Zinc	U	2450	mg/kg	0.50	12	51
Total Organic Carbon	U	2625	%	0.20	[A] 6.1	[A] 0.45
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	[A] < 5.0	[A] < 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	[A] < 1.0	[A] < 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	[A] < 5.0	[A] < 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	[A] < 10	[A] < 10
Benzene	U	2760	µg/kg	1.0	[A] < 1.0	[A] < 1.0
Toluene	U	2760	µg/kg	1.0	[A] < 1.0	[A] < 1.0
Ethylbenzene	U	2760	µg/kg	1.0	[A] < 1.0	[A] < 1.0
m & p-Xylene	U	2760	µg/kg	1.0	[A] < 1.0	[A] < 1.0
o-Xylene	U	2760	µg/kg	1.0	[A] < 1.0	[A] < 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-33216	19-33216
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		899911	899913
			Client Sample ID.:		ES2	ES2
			Sample Location:		RCETP10	RCETP09
			Sample Type:		SOIL	SOIL
			Top Depth (m):		0.30	0.30
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
899911		ES2	RCETP10		A	Amber Glass 250ml
899911		ES2	RCETP10		A	Amber Glass 60ml
899911		ES2	RCETP10		A	Plastic Tub 500g
899913		ES2	RCETP09		A	Amber Glass 250ml
899913		ES2	RCETP09		A	Amber Glass 60ml
899913		ES2	RCETP09		A	Plastic Tub 500g

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
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N	Unaccredited
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SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
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Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Amended Report

Report No.:	19-32803-2		
Initial Date of Issue:	09-Oct-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A14 LVP/RCE		
Quotation No.:	Q19-18181	**Date Received:**	01-Oct-2019
Order No.:		**Date Instructed:**	02-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	08-Oct-2019
Date Approved:	09-Oct-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd		**Chemtest Job No.:**			19-32803	19-32803
Quotation No.: Q19-18181		**Chemtest Sample ID.:**			897990	897993
		Sample Location:			RCETP06	RCETP07
		Sample Type:			SOIL	SOIL
		Top Depth (m) ($):			1.0	0.3
		Date Sampled ($):			30-Sep-2019	30-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	7.1	18
pH	U	2010		4.0	7.3	6.5
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	15	13
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	24	23
Copper	U	2450	mg/kg	0.50	14	10
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	32	22
Lead	U	2450	mg/kg	0.50	15	22
Selenium	U	2450	mg/kg	0.20	< 0.20	0.72
Zinc	U	2450	mg/kg	0.50	74	59
Total Organic Carbon	U	2625	%	0.20	0.28	1.3
Total TPH >C6-C40	U	2670	mg/kg	10	< 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		< 10
Benzene	U	2760	µg/kg	1.0		< 1.0
Toluene	U	2760	µg/kg	1.0		1.5
Ethylbenzene	U	2760	µg/kg	1.0		< 1.0
m & p-Xylene	U	2760	µg/kg	1.0		< 1.0
o-Xylene	U	2760	µg/kg	1.0		< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32803	19-32803
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		897990	897993
			Sample Location:		RCETP06	RCETP07
			Sample Type:		SOIL	SOIL
			Top Depth (m) ($):		1.0	0.3
			Date Sampled ($):		30-Sep-2019	30-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Chemtest
The right chemistry to deliver results

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
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Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Amended Report

Report No.:	19-32803-2		
Initial Date of Issue:	09-Oct-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A14 LVP/RCE		
Quotation No.:	Q19-18181	**Date Received:**	01-Oct-2019
Order No.:		**Date Instructed:**	02-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	08-Oct-2019
Date Approved:	09-Oct-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd		**Chemtest Job No.:**			19-32803	19-32803
Quotation No.: Q19-18181		**Chemtest Sample ID.:**			897990	897993
		Sample Location:			RCETP06	RCETP07
		Sample Type:			SOIL	SOIL
		Top Depth (m) ($):			1.0	0.3
		Date Sampled ($):			30-Sep-2019	30-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	7.1	18
pH	U	2010		4.0	7.3	6.5
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	< 0.40
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	15	13
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	24	23
Copper	U	2450	mg/kg	0.50	14	10
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	32	22
Lead	U	2450	mg/kg	0.50	15	22
Selenium	U	2450	mg/kg	0.20	< 0.20	0.72
Zinc	U	2450	mg/kg	0.50	74	59
Total Organic Carbon	U	2625	%	0.20	0.28	1.3
Total TPH >C6-C40	U	2670	mg/kg	10	< 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		< 10
Benzene	U	2760	µg/kg	1.0		< 1.0
Toluene	U	2760	µg/kg	1.0		1.5
Ethylbenzene	U	2760	µg/kg	1.0		< 1.0
m & p-Xylene	U	2760	µg/kg	1.0		< 1.0
o-Xylene	U	2760	µg/kg	1.0		< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A14 LVP/RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-32803	19-32803
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		897990	897993
			Sample Location:		RCETP06	RCETP07
			Sample Type:		SOIL	SOIL
			Top Depth (m) ($):		1.0	0.3
			Date Sampled ($):		30-Sep-2019	30-Sep-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

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Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Amended Report

Report No.:	19-33216-2		
Initial Date of Issue:	16-Oct-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40 RCE/LVP		
Quotation No.:	Q19-18166	**Date Received:**	03-Oct-2019
Order No.:		**Date Instructed:**	10-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	16-Oct-2019
Date Approved:	16-Oct-2019		
Approved By:			

Details: Robert Monk, Technical Manager

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Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-33216	19-33216
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		899911	899913
			Client Sample ID.:		ES2	ES2
			Sample Location:		RCETP10	RCETP09
			Sample Type:		SOIL	SOIL
			Top Depth (m) ($):		0.30	0.30
			Date Sampled ($):		02-Oct-2019	02-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	21	16
pH	U	2010		4.0	5.3	7.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.58	0.41
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	6.9	11
Cadmium	U	2450	mg/kg	0.10	0.11	0.13
Chromium	U	2450	mg/kg	1.0	8.5	21
Copper	U	2450	mg/kg	0.50	5.4	14
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	7.4	21
Lead	U	2450	mg/kg	0.50	11	30
Selenium	U	2450	mg/kg	0.20	0.95	0.74
Zinc	U	2450	mg/kg	0.50	12	51
Total Organic Carbon	U	2625	%	0.20	6.1	0.45
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10	< 10
Benzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**	19-33216	19-33216
Quotation No.: Q19-18166				**Chemtest Sample ID.:**	899911	899913
				Client Sample ID.:	ES2	ES2
				Sample Location:	RCETP10	RCETP09
				Sample Type:	SOIL	SOIL
				Top Depth (m) ($):	0.30	0.30
				Date Sampled ($):	02-Oct-2019	02-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

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I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Amended Report

Report No.:	19-33216-2		
Initial Date of Issue:	16-Oct-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40 RCE/LVP		
Quotation No.:	Q19-18166	**Date Received:**	03-Oct-2019
Order No.:		**Date Instructed:**	10-Oct-2019
No. of Samples:	2		
Turnaround (Wkdays):	5	**Results Due:**	16-Oct-2019
Date Approved:	16-Oct-2019		
Approved By:			

Details: Robert Monk, Technical Manager

Chemtest
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Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-33216	19-33216
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		899911	899913
			Client Sample ID.:		ES2	ES2
			Sample Location:		RCETP10	RCETP09
			Sample Type:		SOIL	SOIL
			Top Depth (m) ($):		0.30	0.30
			Date Sampled ($):		02-Oct-2019	02-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Moisture	N	2030	%	0.020	21	16
pH	U	2010		4.0	5.3	7.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.58	0.41
Cyanide (Total)	U	2300	mg/kg	0.50	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	6.9	11
Cadmium	U	2450	mg/kg	0.10	0.11	0.13
Chromium	U	2450	mg/kg	1.0	8.5	21
Copper	U	2450	mg/kg	0.50	5.4	14
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	7.4	21
Lead	U	2450	mg/kg	0.50	11	30
Selenium	U	2450	mg/kg	0.20	0.95	0.74
Zinc	U	2450	mg/kg	0.50	12	51
Total Organic Carbon	U	2625	%	0.20	6.1	0.45
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10	< 10
Benzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10

Results - Soil

Project: Q0083 A40 RCE/LVP

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**	19-33216	19-33216
Quotation No.: Q19-18166				**Chemtest Sample ID.:**	899911	899913
				Client Sample ID.:	ES2	ES2
				Sample Location:	RCETP10	RCETP09
				Sample Type:	SOIL	SOIL
				Top Depth (m) ($):	0.30	0.30
				Date Sampled ($):	02-Oct-2019	02-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**		
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30

Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.

Report Information

Key

U	UKAS accredited
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T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

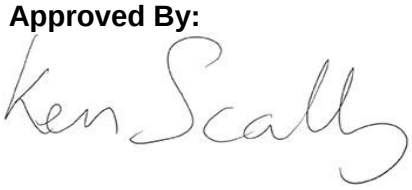
Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Amended Report

Report No.:	19-34430-3		
Initial Date of Issue:	22-Oct-2019	**Date of Re-Issue:**	11-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40		
Quotation No.:	Q19-18166	**Date Received:**	14-Oct-2019
Order No.:		**Date Instructed:**	15-Oct-2019
No. of Samples:	3		
Turnaround (Wkdays):	41	**Results Due:**	10-Dec-2019
Date Approved:	11-Dec-2019		

Approved By:



Details: Ken Scally, Technical Director

Results - Leachate

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd				**Chemtest Job No.:**		19-34430
Quotation No.: Q19-18166				**Chemtest Sample ID.:**		906004
				Client Sample ID.:		ES2
				Sample Location:		RCE-TP03
				Sample Type:		SOIL
				Top Depth (m) ($):		0.30
				Date Sampled ($):		03-Oct-2019
Determinand	**Accred.**	**SOP**	**Type**	**Units**	**LOD**	
pH	U	1010	2:1		N/A	8.7
Ammoniacal Nitrogen	U	1220	2:1	mg/l	0.050	0.54
Ammoniacal Nitrogen	U	1220	2:1	mg/kg	0.010	1.1
Cyanide (Total)	U	1300	2:1	mg/l	0.050	< 0.050

Chemtest
The right chemistry to deliver results

Results - Soil

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-34430	19-34430	19-34430
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		906004	906007	906010
			Client Sample ID.:		ES2	ES4	ES2
			Sample Location:		RCE-TP03	RCE-TP04	RCE-TP06
			Sample Type:		SOIL	SOIL	SOIL
			Top Depth (m) ($):		0.30	1.00	0.30
			Date Sampled ($):		03-Oct-2019	03-Oct-2019	03-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Moisture	N	2030	%	0.020	14	8.8	16
pH	U	2010		4.0	6.2	7.6	6.3
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	< 0.40	3.4	1.7
Cyanide (Total)	U	2300	mg/kg	0.50	0.90	< 0.50	< 0.50
Arsenic	U	2450	mg/kg	1.0	19	14	8.0
Cadmium	U	2450	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Chromium	U	2450	mg/kg	1.0	20	25	26
Copper	U	2450	mg/kg	0.50	18	28	16
Mercury	U	2450	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Nickel	U	2450	mg/kg	0.50	41	34	28
Lead	U	2450	mg/kg	0.50	17	16	19
Selenium	U	2450	mg/kg	0.20	0.36	0.26	< 0.20
Zinc	U	2450	mg/kg	0.50	62	73	58
Total Organic Carbon	U	2625	%	0.20	0.52	0.40	0.37
Total TPH >C6-C40	U	2670	mg/kg	10	< 10	< 10	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0		< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0		< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	< 1.0		< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	< 1.0		< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	< 5.0		< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	< 10		< 10
Benzene	U	2760	µg/kg	1.0	< 1.0		< 1.0
Toluene	U	2760	µg/kg	1.0	< 1.0		< 1.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0		< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0		< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0		< 1.0

Results - Soil

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd					19-34430	19-34430	19-34430
Quotation No.: Q19-18166				**Chemtest Sample ID.:**	906004	906007	906010
				Client Sample ID.:	ES2	ES4	ES2
				Sample Location:	RCE-TP03	RCE-TP04	RCE-TP06
				Sample Type:	SOIL	SOIL	SOIL
				Top Depth (m) ($):	0.30	1.00	0.30
				Date Sampled ($):	03-Oct-2019	03-Oct-2019	03-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Naphthalene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]anthracene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Chrysene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	< 2.0	< 2.0	< 2.0
Total Phenols	U	2920	mg/kg	0.30	< 0.30	< 0.30	< 0.30

Results - 2 Stage WAC

Project: Q0083 A40 LVP

							Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	19-34430								
Chemtest Sample ID:	906004								
Sample Ref:									
Sample ID:	ES2								
Sample Location:	RCE-TP03								
Top Depth (m) ($):	0.30								
Bottom Depth (m) ($):									
Sampling Date ($):	03-Oct-2019								
Determinand	**SOP**	**Accred.**	**Units**				**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon							3	5	6
Loss on Ignition							--	--	10
Total BTEX							6	--	--
Total PCBs (7 congeners)							1	--	--
TPH Total WAC (Mineral Oil)							500	--	--
Total (of 17) PAHs							100	--	--
pH							--	>6	--
Acid Neutralisation Capacity							--	To evaluate	To evaluate
Eluate Analysis			**2:1 mg/l**	**8:1 mg/l**	**2:1 mg/kg**	**Cumulative mg/kg 10:1**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0050		< 0.050		0.5	2	25
Barium	1450	U	0.0030		< 0.50		20	100	300
Cadmium	1450	U	< 0.00010		< 0.010		0.04	1	5
Chromium	1450	U	0.038		0.075		0.5	10	70
Copper	1450	U	0.0084		< 0.050		2	50	100
Mercury	1450	U	< 0.00050		< 0.0010		0.01	0.2	2
Molybdenum							0.5	10	30
Nickel	1450	U	< 0.0010		< 0.050		0.4	10	40
Lead	1450	U	0.0017		< 0.010		0.5	10	50
Antimony							0.06	0.7	5
Selenium	1450	U	< 0.0010		< 0.010		0.1	0.5	7
Zinc	1450	U	0.042		< 0.50		4	50	200
Chloride	1220	U	6.1		12		800	15000	25000
Fluoride							10	150	500
Sulphate							1000	20000	50000
Total Dissolved Solids							4000	60000	100000
Phenol Index	1920	U	< 0.030		< 0.30		1	-	-
Dissolved Organic Carbon							500	800	1000

Solid Information	
Dry mass of test portion/kg	
Moisture (%)	

Leachate Test Information	
Leachant volume 1st extract/l	0.322
Leachant volume 2nd extract/l	
Eluant recovered from 1st extract/l	0.149

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2300	Cyanides & Thiocyanate in Soils	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Allkaline extraction followed by colorimetric determination using Automated Flow Injection Analyser.
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS
2920	Phenols in Soils by HPLC	Phenolic compounds including Resorcinol, Phenol, Methylphenols, Dimethylphenols, 1-Naphthol and TrimethylphenolsNote: chlorophenols are excluded.	60:40 methanol/water mixture extraction, followed by HPLC determination using electrochemical detection.
640	Characterisation of Waste (Leaching C10)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge
650	Characterisation of Waste (Leaching WAC)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

Report Information

Key

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D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

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All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

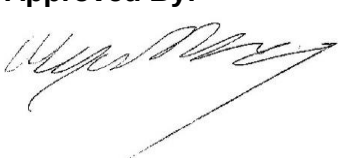
Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Final Report

Report No.:	19-35896-1		
Initial Date of Issue:	01-Nov-2019		
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40-RCE		
Quotation No.:	Q19-18181	**Date Received:**	25-Oct-2019
Order No.:		**Date Instructed:**	25-Oct-2019
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	31-Oct-2019
Date Approved:	01-Nov-2019		

Approved By:



Details: Glynn Harvey, Laboratory Manager

Chemtest
The right chemistry to deliver results

Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-35896	19-35896	19-35896	19-35896
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		913174	913175	913176	913177
			Sample Location:		SW1	SW2	SW3	SW4
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		24-Oct-2019	24-Oct-2019	24-Oct-2019	24-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A	9.0	8.9	8.6	9.0
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	5.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	13	12	160	13
Alkalinity (Total)	U	1220	mg/l	10	58	120	40	37
Chloride	U	1220	mg/l	1.0	29	56	22	22
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.17	< 0.050	0.30	0.22
Sulphate	U	1220	mg/l	1.0	12	15	< 1.0	< 1.0
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	12	30	< 5.0	20
Total Hardness as CaCO3	U	1270	mg/l	15	38	85	< 15	59
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	1.6	1.5
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	1.9	1.9
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	14	14
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	1.0	1.1
Zinc (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	16	14
Dissolved Organic Carbon	U	1610	mg/l	2.0	8.7	7.5	49	15
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10	< 10	< 10
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0

Chemtest
The right chemistry to deliver results

Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-35896	19-35896	19-35896	19-35896
Quotation No.: Q19-18181			**Chemtest Sample ID.:**		913174	913175	913176	913177
			Sample Location:		SW1	SW2	SW3	SW4
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		24-Oct-2019	24-Oct-2019	24-Oct-2019	24-Oct-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Final Report

Report No.:	19-37271-1
Initial Date of Issue:	18-Nov-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40-RCE
Quotation No.:	Q19-18166
Order No.:	
No. of Samples:	16
Turnaround (Wkdays):	5
Date Approved:	18-Nov-2019
Approved By:	
Details:	Amy Parekh-Pross, Technical Projects Manager

Date Received:	06-Nov-2019
Date Instructed:	11-Nov-2019
Results Due:	15-Nov-2019

Chemtest
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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	920218	920219	920220	920221	920222	920223	920224	920225	920226	920227
					Client Sample ID.:	W1	W1	W1	W1	W1	W1	W1	W1	W1	W1
					Sample Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
Determinand	**Accred.**	**SOP**	**Units**	**LOD**											
pH	U	1010		N/A		[A] 7.7	[A] 7.5	[A] 7.7	[A] 7.6	[A] 7.4	[A] 7.4	[A] 7.6	[A] 7.5	[A] 7.5	[A] 8.7
Alkalinity (Total)	U	1220	mg/l	10		[A] 86	[A] 53	[A] 98	[A] 68	[A] 93	[A] 480	[A] 76	[A] 250	[A] 180	[A] 74
Chloride	U	1220	mg/l	1.0		[A] 70	[A] 63	[A] 14	[A] 10	[A] 25	[A] 25	[A] 14	[A] 25	[A] 18	[A] 11
Ammoniacal Nitrogen	U	1220	mg/l	0.050		[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphate	U	1220	mg/l	1.0		[A] 14	[A] 14	[A] 12	[A] 8.1	[A] 34	[A] 15	[A] 12	[A] 40	[A] 14	[A] 8.9
Cyanide (Total)	U	1300	mg/l	0.050		[A] 0.31	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphide	U	1325	mg/l	0.050		[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] 0.065	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Calcium	U	1415	mg/l	5.0		[A] 18	[A] 14	[A] 13	[A] 14	[A] 14	[A] 87	[A] 43	[A] 60	[A] 24	[A] 12
Total Hardness as CaCO3	U	1270	mg/l	15		[A] 50	[A] 48	[A] 54	[A] 49	[A] 51	[A] 240	[A] 120	[A] 200	[A] 97	[A] 39
Arsenic (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080		[A] < 0.080	[A] 0.11	[A] < 0.080	[A] < 0.080	[A] 0.14	[A] < 0.080	[A] < 0.080	[A] 0.095	[A] < 0.080	[A] < 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] 2.0	[A] < 1.0	[A] 4.5	[A] < 1.0	[A] 1.4	[A] < 1.0	[A] 1.5	[A] < 1.0	[A] 2.1
Mercury (Dissolved)	U	1450	µg/l	0.50		[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] 1.6	[A] 1.9	[A] < 1.0	[A] 2.5	[A] 9.9	[A] < 1.0	[A] 18	[A] < 1.0	[A] < 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] 1.1	[A] < 1.0	[A] 2.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		[A] 6.2	[A] 58	[A] 42	[A] 11	[A] 18	[A] 14	[A] 27	[A] 210	[A] 13	[A] 82
Dissolved Organic Carbon	U	1610	mg/l	2.0		12	7.9	10	19	6.9	11	3.7	3.8	5.2	7.1
Total TPH >C6-C40	U	1670	µg/l	10		[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10
Naphthalene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthylene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluorene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Phenanthrene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Anthracene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluoranthene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Pyrene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Chrysene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010		[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10		[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Total Phenols	U	1920	mg/l	0.030		[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030

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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		920228	920229	920230	920231	920232	920233
			Client Sample ID.:		W1	W1	W1	W1	W1	W1
			Sample Location:		BH11	BH12	BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER
Determinand	**Accred.**	**SOP**	**Units**	**LOD**						
pH	U	1010		N/A	[A] 7.9	[A] 7.7	[A] 7.6	[A] 7.6	[A] 7.4	[A] 7.5
Alkalinity (Total)	U	1220	mg/l	10	[A] 180	[A] 75	[A] 62	[A] 140	[A] 72	[A] 23
Chloride	U	1220	mg/l	1.0	[A] 16	[A] 51	[A] 31	[A] 20	[A] 20	[A] 19
Ammoniacal Nitrogen	U	1220	mg/l	0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphate	U	1220	mg/l	1.0	[A] 14	[A] 26	[A] 20	[A] 20	[A] 14	[A] 6.3
Cyanide (Total)	U	1300	mg/l	0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphide	U	1325	mg/l	0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Calcium	U	1415	mg/l	5.0	[A] 53	[A] 17	[A] 9.8	[A] 24	[A] 13	[A] 7.8
Total Hardness as CaCO3	U	1270	mg/l	15	[A] 150	[A] 88	[A] 57	[A] 86	[A] 40	[A] 25
Arsenic (Dissolved)	U	1450	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	[A] < 0.080	[A] < 0.080	[A] < 0.080	[A] 0.17	[A] 0.11	[A] 0.096
Chromium (Dissolved)	U	1450	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	[A] 4.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	[A] < 1.0	[A] < 1.0	[A] 1.5	[A] 1.7	[A] < 1.0	[A] < 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	[A] 1.3	[A] < 1.0	[A] < 1.0	[A] 1.9	[A] < 1.0	[A] < 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] 1.5	[A] < 1.0	[A] < 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	[A] 40	[A] 32	[A] 43	[A] 32	[A] 14	[A] 32
Dissolved Organic Carbon	U	1610	mg/l	2.0	6.8	3.9	4.0	4.4	4.4	6.0
Total TPH >C6-C40	U	1670	µg/l	10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10
Naphthalene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthylene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluorene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Phenanthrene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Anthracene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluoranthene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Pyrene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Chrysene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Total Phenols	U	1920	mg/l	0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920218		W1	BH01		A	Coloured Winchester 1000ml
920218		W1	BH01		A	EPA Vial 40ml
920218		W1	BH01		A	Plastic Bottle 1000ml
920219		W1	BH02		A	Coloured Winchester 1000ml
920219		W1	BH02		A	EPA Vial 40ml
920219		W1	BH02		A	Plastic Bottle 1000ml
920220		W1	BH03		A	Coloured Winchester 1000ml
920220		W1	BH03		A	EPA Vial 40ml
920220		W1	BH03		A	Plastic Bottle 1000ml
920221		W1	BH04		A	Coloured Winchester 1000ml
920221		W1	BH04		A	EPA Vial 40ml
920221		W1	BH04		A	Plastic Bottle 1000ml
920222		W1	BH05		A	Coloured Winchester 1000ml
920222		W1	BH05		A	EPA Vial 40ml
920222		W1	BH05		A	Plastic Bottle 1000ml
920223		W1	BH06		A	Coloured Winchester 1000ml
920223		W1	BH06		A	EPA Vial 40ml
920223		W1	BH06		A	Plastic Bottle 1000ml
920224		W1	BH07		A	Coloured Winchester 1000ml
920224		W1	BH07		A	EPA Vial 40ml
920224		W1	BH07		A	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920225		W1	BH08		A	Coloured Winchester 1000ml
920225		W1	BH08		A	EPA Vial 40ml
920225		W1	BH08		A	Plastic Bottle 1000ml
920226		W1	BH09		A	Coloured Winchester 1000ml
920226		W1	BH09		A	EPA Vial 40ml
920226		W1	BH09		A	Plastic Bottle 1000ml
920227		W1	BH10		A	Coloured Winchester 1000ml
920227		W1	BH10		A	EPA Vial 40ml
920227		W1	BH10		A	Plastic Bottle 1000ml
920228		W1	BH11		A	Coloured Winchester 1000ml
920228		W1	BH11		A	EPA Vial 40ml
920228		W1	BH11		A	Plastic Bottle 1000ml
920229		W1	BH12		A	Coloured Winchester 1000ml
920229		W1	BH12		A	EPA Vial 40ml
920229		W1	BH12		A	Plastic Bottle 1000ml
920230		W1	BH13		A	Coloured Winchester 1000ml
920230		W1	BH13		A	EPA Vial 40ml
920230		W1	BH13		A	Plastic Bottle 1000ml
920231		W1	BH14		A	Coloured Winchester 1000ml
920231		W1	BH14		A	EPA Vial 40ml
920231		W1	BH14		A	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920232		W1	BH15		A	Coloured Winchester 1000ml
920232		W1	BH15		A	EPA Vial 40ml
920232		W1	BH15		A	Plastic Bottle 1000ml
920233		W1	BH16		A	Coloured Winchester 1000ml
920233		W1	BH16		A	EPA Vial 40ml
920233		W1	BH16		A	Plastic Bottle 1000ml

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

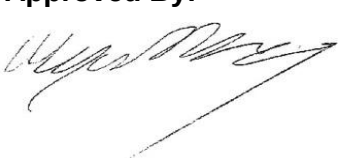
UKAS TESTING
2183

Final Report

Report No.:	19-39568-1
Initial Date of Issue:	05-Dec-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:		**Date Received:**	26-Nov-2019
Order No.:		**Date Instructed:**	26-Nov-2019
No. of Samples:	4		
Turnaround (Wkdays):	6	**Results Due:**	03-Dec-2019
Date Approved:	05-Dec-2019		

Approved By:



Details: Glynn Harvey, Laboratory Manager

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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-39568	19-39568	19-39568	19-39568
Quotation No.:			**Chemtest Sample ID.:**		932738	932739	932740	932741
			Client Sample ID.:		W2	W2	W2	W2
			Sample Location:		SW1	SW2	SW3	SW4
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A	6.7	7.0	6.6	6.9
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	18	< 10	110	41
Chloride	U	1220	mg/l	1.0	23	32	12	21
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.051	0.45	0.11	< 0.050
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	71	23	< 5.0	13
Total Hardness as CaCO3	U	1270	mg/l	15	200	64	34	40
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Beryllium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	3.8	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	1.1	1.6	< 1.0	1.7
Manganese (Dissolved)	U	1450	µg/l	1.0	16	23	90	12
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Antimony (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	4.0	5.1	8.4	4.1
Mercury Low Level	U	1460	µg/l	0.010	< 0.010	< 0.010	0.025	< 0.010
Dissolved Organic Carbon	U	1610	mg/l	2.0	14	11	25	18
Mineral Oil	N	1670	µg/l	10	< 10	< 10	< 10	< 10
TPH >C6-C10	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C10-C21	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C21-C40	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010

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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-39568	19-39568	19-39568	19-39568
Quotation No.:			**Chemtest Sample ID.:**		932738	932739	932740	932741
			Client Sample ID.:		W2	W2	W2	W2
			Sample Location:		SW1	SW2	SW3	SW4
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1460	Mercury low-level in Waters by AFS	Mercury	Atomic Fluorescence Spectrometry, with collimated UV source, wavelength 253.7 nm.
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

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Amended Report

Report No.:	19-38276-2		
Initial Date of Issue:	28-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Phil Darby Hugh Woodroffe		
Project	Q0083 A40 LVP		
Quotation No.:	Q19-18166	**Date Received:**	15-Nov-2019
Order No.:		**Date Instructed:**	15-Nov-2019
No. of Samples:	16		
Turnaround (Wkdays):	5	**Results Due:**	21-Nov-2019
Date Approved:	28-Nov-2019		

Approved By:

Details: Glynn Harvey, Laboratory Manager

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925354	925355	925356	925357	925358	925359	925360	925361	925362
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
pH	U	1010		N/A	7.8	7.5	7.3	7.4	7.1	7.1	7.3	8.5	8.4
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	5.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	91	150	130	140	29	130	120	520	520
Alkalinity (Total)	U	1220	mg/l	10	79	84	40	51	95	510	71	130	180
Chloride	U	1220	mg/l	1.0	70	61	10	10	24	21	13	16	18
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.067	0.062	< 0.050	< 0.050	< 0.050	0.078	< 0.050	< 0.050	0.10
Sulphate	U	1220	mg/l	1.0	13	18	5.3	7.5	32	11	12	27	15
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	35	35	28	22	31	69	73	37	43
Total Hardness as CaCO3	U	1270	mg/l	15	93	100	81	65	90	190	200	110	140
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.5	< 1.0	1.2	9.6
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	1.5	2.6	< 1.0	5.2	< 1.0	1.6	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.60	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	9.2	< 1.0	1.6	3.0	9.8	< 1.0	16	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.1	< 1.0	4.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	2.5	1.9	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	15	58	4.9	38	34	15	11	38	< 1.0
Dissolved Organic Carbon	U	1610	mg/l	2.0	9.5	8.9	8.2	8.6	8.8	17	8.5	7.8	7.6
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	24
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	210
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3700
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3900
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	6.3
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1100
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	59
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	1200
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	5100
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925354	925355	925356	925357	925358	925359	925360	925361	925362
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925363	925364	925365	925366	925367	925368	925369
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH10	BH11	BH12	BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
pH	U	1010		N/A	8.4	8.0	7.9	7.9	7.9	7.7	7.7
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	540	980	450	140	150	140	120
Alkalinity (Total)	U	1220	mg/l	10	68	170	96	67	140	71	60
Chloride	U	1220	mg/l	1.0	11	15	51	28	18	20	20
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.054	0.077	< 0.050	< 0.050	< 0.050	0.057	0.057
Sulphate	U	1220	mg/l	1.0	8.8	15	27	20	17	14	7.3
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	34	51	40	27	40	31	24
Total Hardness as CaCO3	U	1270	mg/l	15	99	140	150	96	120	89	67
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	4.0	2.6	< 1.0	1.9	1.9	2.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	1.1	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	3.2	< 1.0	2.7	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	31	10	19	35	20	14	6.9
Dissolved Organic Carbon	U	1610	mg/l	2.0	7.2	10	5.9	7.0	7.0	6.9	6.3
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925363	925364	925365	925366	925367	925368	925369
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH10	BH11	BH12	BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

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Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Amended Report

Report No.:	19-37271-2		
Initial Date of Issue:	18-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40-RCE		
Quotation No.:	Q19-18166	**Date Received:**	06-Nov-2019
Order No.:		**Date Instructed:**	11-Nov-2019
No. of Samples:	16		
Turnaround (Wkdays):	5	**Results Due:**	15-Nov-2019
Date Approved:	18-Nov-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	920218	920219	920220	920221	920222	920223	920224	920225	920226
					Client Sample ID.:	W1	W1	W1	W1	W1	W1	W1	W1	W1
					Sample Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Date Sampled ($):	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**										
pH	U	1010		N/A		7.7	7.5	7.7	7.6	7.4	7.4	7.6	7.5	7.5
Alkalinity (Total)	U	1220	mg/l	10		86	53	98	68	93	480	76	250	180
Chloride	U	1220	mg/l	1.0		70	63	14	10	25	25	14	25	18
Ammoniacal Nitrogen	U	1220	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0		14	14	12	8.1	34	15	12	40	14
Cyanide (Total)	U	1300	mg/l	0.050		0.31	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050		[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] 0.065	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050
Calcium	U	1415	mg/l	5.0		18	14	13	14	14	87	43	60	24
Total Hardness as CaCO3	U	1270	mg/l	15		50	48	54	49	51	240	120	200	97
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0	1.1
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	0.11	< 0.080	< 0.080	0.14	< 0.080	< 0.080	0.095	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		< 1.0	2.0	< 1.0	4.5	< 1.0	1.4	< 1.0	1.5	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.6	1.9	< 1.0	2.5	9.9	< 1.0	18	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.1	< 1.0	2.1	< 1.0	< 1.0	< 1.0	1.1	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		6.2	58	42	11	18	14	27	210	13
Dissolved Organic Carbon	U	1610	mg/l	2.0		12	7.9	10	19	6.9	11	3.7	3.8	5.2
Total TPH >C6-C40	U	1670	µg/l	10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030		< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	920227	920228	920229	920230	920231	920232	920233
					Client Sample ID.:	W1	W1	W1	W1	W1	W1	W1
					Sample Location:	BH10	BH11	BH12	BH13	BH14	BH15	BH16
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Date Sampled ($):	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
pH	U	1010		N/A		8.7	7.9	7.7	7.6	7.6	7.4	7.5
Alkalinity (Total)	U	1220	mg/l	10		74	180	75	62	140	72	23
Chloride	U	1220	mg/l	1.0		11	16	51	31	20	20	19
Ammoniacal Nitrogen	U	1220	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0		8.9	14	26	20	20	14	6.3
Cyanide (Total)	U	1300	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050		[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050
Calcium	U	1415	mg/l	5.0		12	53	17	9.8	24	13	7.8
Total Hardness as CaCO3	U	1270	mg/l	15		39	150	88	57	86	40	25
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	< 0.080	< 0.080	< 0.080	0.17	0.11	0.096
Chromium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		2.1	4.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	1.5	1.7	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.3	< 1.0	< 1.0	1.9	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	1.1	< 1.0	1.5	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		82	40	32	43	32	14	32
Dissolved Organic Carbon	U	1610	mg/l	2.0		7.1	6.8	3.9	4.0	4.4	4.4	6.0
Total TPH >C6-C40	U	1670	µg/l	10		< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030		< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920218		W1	BH01	05-Nov-2019	B	Coloured Winchester 1000ml
920218		W1	BH01	05-Nov-2019	B	EPA Vial 40ml
920218		W1	BH01	05-Nov-2019	B	Plastic Bottle 1000ml
920219		W1	BH02	05-Nov-2019	B	Coloured Winchester 1000ml
920219		W1	BH02	05-Nov-2019	B	EPA Vial 40ml
920219		W1	BH02	05-Nov-2019	B	Plastic Bottle 1000ml
920220		W1	BH03	05-Nov-2019	B	Coloured Winchester 1000ml
920220		W1	BH03	05-Nov-2019	B	EPA Vial 40ml
920220		W1	BH03	05-Nov-2019	B	Plastic Bottle 1000ml
920221		W1	BH04	05-Nov-2019	B	Coloured Winchester 1000ml
920221		W1	BH04	05-Nov-2019	B	EPA Vial 40ml
920221		W1	BH04	05-Nov-2019	B	Plastic Bottle 1000ml
920222		W1	BH05	05-Nov-2019	B	Coloured Winchester 1000ml
920222		W1	BH05	05-Nov-2019	B	EPA Vial 40ml
920222		W1	BH05	05-Nov-2019	B	Plastic Bottle 1000ml
920223		W1	BH06	05-Nov-2019	B	Coloured Winchester 1000ml
920223		W1	BH06	05-Nov-2019	B	EPA Vial 40ml
920223		W1	BH06	05-Nov-2019	B	Plastic Bottle 1000ml
920224		W1	BH07	05-Nov-2019	B	Coloured Winchester 1000ml
920224		W1	BH07	05-Nov-2019	B	EPA Vial 40ml
920224		W1	BH07	05-Nov-2019	B	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920225		W1	BH08	05-Nov-2019	B	Coloured Winchester 1000ml
920225		W1	BH08	05-Nov-2019	B	EPA Vial 40ml
920225		W1	BH08	05-Nov-2019	B	Plastic Bottle 1000ml
920226		W1	BH09	05-Nov-2019	B	Coloured Winchester 1000ml
920226		W1	BH09	05-Nov-2019	B	EPA Vial 40ml
920226		W1	BH09	05-Nov-2019	B	Plastic Bottle 1000ml
920227		W1	BH10	05-Nov-2019	B	Coloured Winchester 1000ml
920227		W1	BH10	05-Nov-2019	B	EPA Vial 40ml
920227		W1	BH10	05-Nov-2019	B	Plastic Bottle 1000ml
920228		W1	BH11	05-Nov-2019	B	Coloured Winchester 1000ml
920228		W1	BH11	05-Nov-2019	B	EPA Vial 40ml
920228		W1	BH11	05-Nov-2019	B	Plastic Bottle 1000ml
920229		W1	BH12	05-Nov-2019	B	Coloured Winchester 1000ml
920229		W1	BH12	05-Nov-2019	B	EPA Vial 40ml
920229		W1	BH12	05-Nov-2019	B	Plastic Bottle 1000ml
920230		W1	BH13	05-Nov-2019	B	Coloured Winchester 1000ml
920230		W1	BH13	05-Nov-2019	B	EPA Vial 40ml
920230		W1	BH13	05-Nov-2019	B	Plastic Bottle 1000ml
920231		W1	BH14	05-Nov-2019	B	Coloured Winchester 1000ml
920231		W1	BH14	05-Nov-2019	B	EPA Vial 40ml
920231		W1	BH14	05-Nov-2019	B	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920232		W1	BH15	05-Nov-2019	B	Coloured Winchester 1000ml
920232		W1	BH15	05-Nov-2019	B	EPA Vial 40ml
920232		W1	BH15	05-Nov-2019	B	Plastic Bottle 1000ml
920233		W1	BH16	05-Nov-2019	B	Coloured Winchester 1000ml
920233		W1	BH16	05-Nov-2019	B	EPA Vial 40ml
920233		W1	BH16	05-Nov-2019	B	Plastic Bottle 1000ml

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest
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Email: info@chemtest.com

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Amended Report

Report No.:	19-37271-2		
Initial Date of Issue:	18-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Hugh Woodroffe		
Project	Q0083 A40-RCE		
Quotation No.:	Q19-18166	**Date Received:**	06-Nov-2019
Order No.:		**Date Instructed:**	11-Nov-2019
No. of Samples:	16		
Turnaround (Wkdays):	5	**Results Due:**	15-Nov-2019
Date Approved:	18-Nov-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	920218	920219	920220	920221	920222	920223	920224	920225	920226
					Client Sample ID.:	W1	W1	W1	W1	W1	W1	W1	W1	W1
					Sample Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Date Sampled ($):	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**										
pH	U	1010		N/A		7.7	7.5	7.7	7.6	7.4	7.4	7.6	7.5	7.5
Alkalinity (Total)	U	1220	mg/l	10		86	53	98	68	93	480	76	250	180
Chloride	U	1220	mg/l	1.0		70	63	14	10	25	25	14	25	18
Ammoniacal Nitrogen	U	1220	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0		14	14	12	8.1	34	15	12	40	14
Cyanide (Total)	U	1300	mg/l	0.050		0.31	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050		[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] 0.065	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050
Calcium	U	1415	mg/l	5.0		18	14	13	14	14	87	43	60	24
Total Hardness as CaCO3	U	1270	mg/l	15		50	48	54	49	51	240	120	200	97
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0	1.1
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	0.11	< 0.080	< 0.080	0.14	< 0.080	< 0.080	0.095	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		< 1.0	2.0	< 1.0	4.5	< 1.0	1.4	< 1.0	1.5	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.6	1.9	< 1.0	2.5	9.9	< 1.0	18	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.1	< 1.0	2.1	< 1.0	< 1.0	< 1.0	1.1	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		6.2	58	42	11	18	14	27	210	13
Dissolved Organic Carbon	U	1610	mg/l	2.0		12	7.9	10	19	6.9	11	3.7	3.8	5.2
Total TPH >C6-C40	U	1670	µg/l	10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030		< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Results - Water

Project: Q0083 A40-RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-37271	19-37271	19-37271	19-37271	19-37271	19-37271
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	920227	920228	920229	920230	920231	920232	920233
					Client Sample ID.:	W1	W1	W1	W1	W1	W1	W1
					Sample Location:	BH10	BH11	BH12	BH13	BH14	BH15	BH16
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Date Sampled ($):	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019	05-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**								
pH	U	1010		N/A		8.7	7.9	7.7	7.6	7.6	7.4	7.5
Alkalinity (Total)	U	1220	mg/l	10		74	180	75	62	140	72	23
Chloride	U	1220	mg/l	1.0		11	16	51	31	20	20	19
Ammoniacal Nitrogen	U	1220	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphate	U	1220	mg/l	1.0		8.9	14	26	20	20	14	6.3
Cyanide (Total)	U	1300	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050		[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050
Calcium	U	1415	mg/l	5.0		12	53	17	9.8	24	13	7.8
Total Hardness as CaCO3	U	1270	mg/l	15		39	150	88	57	86	40	25
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	< 0.080	< 0.080	< 0.080	0.17	0.11	0.096
Chromium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		2.1	4.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	1.5	1.7	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.3	< 1.0	< 1.0	1.9	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	1.1	< 1.0	1.5	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		82	40	32	43	32	14	32
Dissolved Organic Carbon	U	1610	mg/l	2.0		7.1	6.8	3.9	4.0	4.4	4.4	6.0
Total TPH >C6-C40	U	1670	µg/l	10		< 10	< 10	< 10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030		< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920218		W1	BH01	05-Nov-2019	B	Coloured Winchester 1000ml
920218		W1	BH01	05-Nov-2019	B	EPA Vial 40ml
920218		W1	BH01	05-Nov-2019	B	Plastic Bottle 1000ml
920219		W1	BH02	05-Nov-2019	B	Coloured Winchester 1000ml
920219		W1	BH02	05-Nov-2019	B	EPA Vial 40ml
920219		W1	BH02	05-Nov-2019	B	Plastic Bottle 1000ml
920220		W1	BH03	05-Nov-2019	B	Coloured Winchester 1000ml
920220		W1	BH03	05-Nov-2019	B	EPA Vial 40ml
920220		W1	BH03	05-Nov-2019	B	Plastic Bottle 1000ml
920221		W1	BH04	05-Nov-2019	B	Coloured Winchester 1000ml
920221		W1	BH04	05-Nov-2019	B	EPA Vial 40ml
920221		W1	BH04	05-Nov-2019	B	Plastic Bottle 1000ml
920222		W1	BH05	05-Nov-2019	B	Coloured Winchester 1000ml
920222		W1	BH05	05-Nov-2019	B	EPA Vial 40ml
920222		W1	BH05	05-Nov-2019	B	Plastic Bottle 1000ml
920223		W1	BH06	05-Nov-2019	B	Coloured Winchester 1000ml
920223		W1	BH06	05-Nov-2019	B	EPA Vial 40ml
920223		W1	BH06	05-Nov-2019	B	Plastic Bottle 1000ml
920224		W1	BH07	05-Nov-2019	B	Coloured Winchester 1000ml
920224		W1	BH07	05-Nov-2019	B	EPA Vial 40ml
920224		W1	BH07	05-Nov-2019	B	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920225		W1	BH08	05-Nov-2019	B	Coloured Winchester 1000ml
920225		W1	BH08	05-Nov-2019	B	EPA Vial 40ml
920225		W1	BH08	05-Nov-2019	B	Plastic Bottle 1000ml
920226		W1	BH09	05-Nov-2019	B	Coloured Winchester 1000ml
920226		W1	BH09	05-Nov-2019	B	EPA Vial 40ml
920226		W1	BH09	05-Nov-2019	B	Plastic Bottle 1000ml
920227		W1	BH10	05-Nov-2019	B	Coloured Winchester 1000ml
920227		W1	BH10	05-Nov-2019	B	EPA Vial 40ml
920227		W1	BH10	05-Nov-2019	B	Plastic Bottle 1000ml
920228		W1	BH11	05-Nov-2019	B	Coloured Winchester 1000ml
920228		W1	BH11	05-Nov-2019	B	EPA Vial 40ml
920228		W1	BH11	05-Nov-2019	B	Plastic Bottle 1000ml
920229		W1	BH12	05-Nov-2019	B	Coloured Winchester 1000ml
920229		W1	BH12	05-Nov-2019	B	EPA Vial 40ml
920229		W1	BH12	05-Nov-2019	B	Plastic Bottle 1000ml
920230		W1	BH13	05-Nov-2019	B	Coloured Winchester 1000ml
920230		W1	BH13	05-Nov-2019	B	EPA Vial 40ml
920230		W1	BH13	05-Nov-2019	B	Plastic Bottle 1000ml
920231		W1	BH14	05-Nov-2019	B	Coloured Winchester 1000ml
920231		W1	BH14	05-Nov-2019	B	EPA Vial 40ml
920231		W1	BH14	05-Nov-2019	B	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
920232		W1	BH15	05-Nov-2019	B	Coloured Winchester 1000ml
920232		W1	BH15	05-Nov-2019	B	EPA Vial 40ml
920232		W1	BH15	05-Nov-2019	B	Plastic Bottle 1000ml
920233		W1	BH16	05-Nov-2019	B	Coloured Winchester 1000ml
920233		W1	BH16	05-Nov-2019	B	EPA Vial 40ml
920233		W1	BH16	05-Nov-2019	B	Plastic Bottle 1000ml

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

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Email: info@chemtest.com

Amended Report

Report No.:	19-38272-2		
Initial Date of Issue:	26-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Phil Darby Hugh Woodroffe		
Project	Q0083 A40 RCE		
Quotation No.:	Q19-18166	**Date Received:**	15-Nov-2019
Order No.:		**Date Instructed:**	15-Nov-2019
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	21-Nov-2019
Date Approved:	26-Nov-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38272	19-38272	19-38272	19-38272
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925331	925332	925333	925334
			Client Sample ID.:		SW1	SW2	SW3	SW4
			Sample Location:		SW2	SW2	SW2	SW2
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A	8.5	8.6	8.7	8.4
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	130	570	260	690
Alkalinity (Total)	U	1220	mg/l	10	61	120	22	78
Chloride	U	1220	mg/l	1.0	39	64	13	24
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.061	0.12	0.078	< 0.050
Sulphate	U	1220	mg/l	1.0	9.9	14	5.8	8.7
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	< 5.0	25	9.8	28
Total Hardness as CaCO3	U	1270	mg/l	15	< 15	71	31	77
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.1	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	75	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	3.8	2.1	1.0	1.3
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	4.5	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	5.3	2.8	12	6.7
Dissolved Organic Carbon	U	1610	mg/l	2.0	4.9	4.8	17	9.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

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I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

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Amended Report

Report No.:	19-38272-2		
Initial Date of Issue:	26-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Phil Darby Hugh Woodroffe		
Project	Q0083 A40 RCE		
Quotation No.:	Q19-18166	**Date Received:**	15-Nov-2019
Order No.:		**Date Instructed:**	15-Nov-2019
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	21-Nov-2019
Date Approved:	26-Nov-2019		

Approved By:

Details: Amy Parekh-Pross, Technical Projects Manager

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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38272	19-38272	19-38272	19-38272
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925331	925332	925333	925334
			Client Sample ID.:		SW1	SW2	SW3	SW4
			Sample Location:		SW2	SW2	SW2	SW2
			Sample Type:		WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A	8.5	8.6	8.7	8.4
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	130	570	260	690
Alkalinity (Total)	U	1220	mg/l	10	61	120	22	78
Chloride	U	1220	mg/l	1.0	39	64	13	24
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.061	0.12	0.078	< 0.050
Sulphate	U	1220	mg/l	1.0	9.9	14	5.8	8.7
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	< 5.0	25	9.8	28
Total Hardness as CaCO3	U	1270	mg/l	15	< 15	71	31	77
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.1	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	75	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	3.8	2.1	1.0	1.3
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	4.5	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	5.3	2.8	12	6.7
Dissolved Organic Carbon	U	1610	mg/l	2.0	4.9	4.8	17	9.0
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Amended Report

Report No.:	19-38276-2		
Initial Date of Issue:	28-Nov-2019	**Date of Re-Issue:**	10-Dec-2019
Client	Quantum Geotechnic Ltd		
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG		
Contact(s):	Phil Darby Hugh Woodroffe		
Project	Q0083 A40 LVP		
Quotation No.:	Q19-18166	**Date Received:**	15-Nov-2019
Order No.:		**Date Instructed:**	15-Nov-2019
No. of Samples:	16		
Turnaround (Wkdays):	5	**Results Due:**	21-Nov-2019
Date Approved:	28-Nov-2019		

Approved By:

Details: Glynn Harvey, Laboratory Manager

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166					**Chemtest Sample ID.:**	925354	925355	925356	925357	925358	925359	925360	925361	925362
					Client Sample ID.:	W2	W2	W2	W2	W2	W2	W2	W2	W2
					Sample Location:	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Date Sampled ($):	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**										
pH	U	1010		N/A		7.8	7.5	7.3	7.4	7.1	7.1	7.3	8.5	8.4
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0		< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	5.0
Chemical Oxygen Demand	U	1100	mg O2/l	10		91	150	130	140	29	130	120	520	520
Alkalinity (Total)	U	1220	mg/l	10		79	84	40	51	95	510	71	130	180
Chloride	U	1220	mg/l	1.0		70	61	10	10	24	21	13	16	18
Ammoniacal Nitrogen	U	1220	mg/l	0.050		0.067	0.062	< 0.050	< 0.050	< 0.050	0.078	< 0.050	< 0.050	0.10
Sulphate	U	1220	mg/l	1.0		13	18	5.3	7.5	32	11	12	27	15
Cyanide (Total)	U	1300	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0		35	35	28	22	31	69	73	37	43
Total Hardness as CaCO3	U	1270	mg/l	15		93	100	81	65	90	190	200	110	140
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.5	< 1.0	1.2	9.6
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		1.5	2.6	< 1.0	5.2	< 1.0	1.6	< 1.0	< 1.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50	< 0.50	0.60	< 0.50	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	9.2	< 1.0	1.6	3.0	9.8	< 1.0	16	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	1.1	< 1.0	4.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	2.5	1.9	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		15	58	4.9	38	34	15	11	38	< 1.0
Dissolved Organic Carbon	U	1610	mg/l	2.0		9.5	8.9	8.2	8.6	8.8	17	8.5	7.8	7.6
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	24
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	210
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3700
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0		< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3900
Aromatic TPH >C5-C7	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	6.3
Aromatic TPH >C21-C35	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1100
Aromatic TPH >C35-C44	N	1675	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	59
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0		< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	1200
Total Petroleum Hydrocarbons	N	1675	µg/l	10		< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	5100

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925354	925355	925356	925357	925358	925359	925360	925361	925362
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

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Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925363	925364	925365	925366	925367	925368	925369
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH10	BH11	BH12	BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
pH	U	1010		N/A	8.4	8.0	7.9	7.9	7.9	7.7	7.7
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	540	980	450	140	150	140	120
Alkalinity (Total)	U	1220	mg/l	10	68	170	96	67	140	71	60
Chloride	U	1220	mg/l	1.0	11	15	51	28	18	20	20
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.054	0.077	< 0.050	< 0.050	< 0.050	0.057	0.057
Sulphate	U	1220	mg/l	1.0	8.8	15	27	20	17	14	7.3
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	U	1325	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	34	51	40	27	40	31	24
Total Hardness as CaCO3	U	1270	mg/l	15	99	140	150	96	120	89	67
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	4.0	2.6	< 1.0	1.9	1.9	2.0	< 1.0
Mercury (Dissolved)	U	1450	µg/l	0.50	< 0.50	< 0.50	< 0.50	1.1	< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	3.2	< 1.0	2.7	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	1.0	< 1.0	< 1.0	< 1.0	1.1	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	31	10	19	35	20	14	6.9
Dissolved Organic Carbon	U	1610	mg/l	2.0	7.2	10	5.9	7.0	7.0	6.9	6.3
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C21-C35	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

Chemtest
The right chemistry to deliver results

Results - Water

Project: Q0083 A40 LVP

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-38276	19-38276	19-38276	19-38276	19-38276	19-38276	19-38276
Quotation No.: Q19-18166			**Chemtest Sample ID.:**		925363	925364	925365	925366	925367	925368	925369
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH10	BH11	BH12	BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Date Sampled ($):		15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019	15-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1325	Sulphide in Waters	Sulphides	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using N,N–dimethyl-pphenylenediamine.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

Report Information

Key

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customerservices@chemtest.com

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

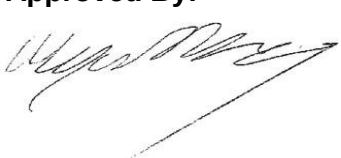
UKAS TESTING
2183

Final Report

Report No.:	19-39569-1
Initial Date of Issue:	05-Dec-2019
Client	Quantum Geotechnic Ltd
Client Address:	Plas Newydd Llanedi Pontarddulais Swansea SA4 0FG
Contact(s):	Hugh Woodroffe
Project	Q0083 A40 RCE

Quotation No.:		**Date Received:**	26-Nov-2019
Order No.:		**Date Instructed:**	03-Dec-2019
No. of Samples:	13		
Turnaround (Wkdays):	5	**Results Due:**	02-Dec-2019
Date Approved:	05-Dec-2019		

Approved By:



Details: Glynn Harvey, Laboratory Manager

Chemtest
The right chemistry to deliver results

Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd					**Chemtest Job No.:**	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569
Quotation No.:					**Chemtest Sample ID.:**	932742	932743	932744	932745	932746	932747	932748	932749	932750
					Client Sample ID.:	W2	W2	W2	W2	W2	W2	W2	W2	W2
					Sample Location:	BH1	BH2	BH3	BH4	BH8	BH9	BH10	BH11	BH12
					Sample Type:	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
					Top Depth (m):	4.12	4.66	0.19	4.70	0.63	0.00	9.55	1.63	1.72
					Date Sampled ($):	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**										
pH	U	1010		N/A		6.5	6.2	6.4	6.4	6.8	7.0	7.0	7.0	6.7
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0		[B] < 4.0	[B] 6.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] 6.0	[B] < 4.0	[B] < 4.0	[B] < 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10		21	< 10	11	11	< 10	16	< 10	< 10	< 10
Chloride	U	1220	mg/l	1.0		63	48	6.8	11	17	18	9.2	14	51
Ammoniacal Nitrogen	U	1220	mg/l	0.050		0.49	0.061	< 0.050	0.21	0.056	0.086	0.16	0.62	1.0
Cyanide (Total)	U	1300	mg/l	0.050		< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0		14	11	8.1	5.0	15	25	10	38	21
Total Hardness as CaCO3	U	1270	mg/l	15		39	35	24	19	61	100	33	110	98
Arsenic (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	1.3	8.9	< 1.0	< 1.0	< 1.0
Beryllium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080		0.30	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	0.32	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0		1.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0		2.0	< 1.0	1.1	1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Manganese (Dissolved)	U	1450	µg/l	1.0		28	33	19	27	680	380	18	38	16
Nickel (Dissolved)	U	1450	µg/l	1.0		< 1.0	2.2	< 1.0	1.4	14	< 1.0	< 1.0	1.4	1.5
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Antimony (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (Dissolved)	U	1450	µg/l	1.0		< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0		41	24	44	13	43	7.9	27	15	33
Mercury Low Level	U	1460	µg/l	0.010		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dissolved Organic Carbon	U	1610	mg/l	2.0		12	7.8	8.0	8.7	8.0	6.9	8.1	11	8.1
Mineral Oil	N	1670	µg/l	10		< 10	< 10	< 10	< 10			< 10	< 10	< 10
TPH >C6-C10	N	1670	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10			< 0.10	< 0.10	< 0.10
TPH >C10-C21	N	1670	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10			< 0.10	< 0.10	< 0.10
TPH >C21-C40	N	1670	µg/l	0.10		< 0.10	< 0.10	< 0.10	< 0.10			< 0.10	< 0.10	< 0.10
Total TPH >C6-C40	U	1670	µg/l	10		< 10	< 10	< 10	< 10			< 10	< 10	< 10
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10						< 0.10	< 0.10			
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0						< 5.0	< 5.0			
Aromatic TPH >C5-C7	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aromatic TPH >C7-C8	N	1675	µg/l	0.10						< 0.10	< 0.10			
Aromatic TPH >C8-C10	N	1675	µg/l	0.10						< 0.10	< 0.10			

Chemtest
The right chemistry to deliver results

Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569	19-39569
Quotation No.:			**Chemtest Sample ID.:**		932742	932743	932744	932745	932746	932747	932748	932749	932750
			Client Sample ID.:		W2	W2	W2	W2	W2	W2	W2	W2	W2
			Sample Location:		BH1	BH2	BH3	BH4	BH8	BH9	BH10	BH11	BH12
			Sample Type:		WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
			Top Depth (m):		4.12	4.66	0.19	4.70	0.63	0.00	9.55	1.63	1.72
			Date Sampled ($):		25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**									
Aromatic TPH >C10-C12	N	1675	µg/l	0.10					< 0.10	< 0.10			
Aromatic TPH >C12-C16	N	1675	µg/l	0.10					< 0.10	< 0.10			
Aromatic TPH >C16-C21	N	1675	µg/l	0.10					< 0.10	< 0.10			
Aromatic TPH >C21-C35	N	1675	µg/l	0.10					< 0.10	< 0.10			
Aromatic TPH >C35-C44	N	1675	µg/l	0.10					< 0.10	< 0.10			
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0					< 5.0	< 5.0			
Total Petroleum Hydrocarbons	N	1675	µg/l	10					< 10	< 10			
Benzene	U	1760	µg/l	1.0					< 1.0	< 1.0			
Toluene	U	1760	µg/l	1.0					< 1.0	< 1.0			
Ethylbenzene	U	1760	µg/l	1.0					< 1.0	< 1.0			
m & p-Xylene	U	1760	µg/l	1.0					< 1.0	< 1.0			
o-Xylene	U	1760	µg/l	1.0					< 1.0	< 1.0			
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030

Chemtest
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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-39569	19-39569	19-39569	19-39569
Quotation No.:			**Chemtest Sample ID.:**		932751	932752	932753	932754
			Client Sample ID.:		W2	W2	W2	W2
			Sample Location:		BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER
			Top Depth (m):		1.21	1.69	5.11	3.41
			Date Sampled ($):		25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A	6.6	7.0	6.4	6.5
Biochemical Oxygen Demand	N	1090	mg O2/l	4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0
Chemical Oxygen Demand	U	1100	mg O2/l	10	< 10	< 10	< 10	< 10
Chloride	U	1220	mg/l	1.0	27	16	17	18
Ammoniacal Nitrogen	U	1220	mg/l	0.050	0.26	0.058	0.058	< 0.050
Cyanide (Total)	U	1300	mg/l	0.050	< 0.050	< 0.050	< 0.050	< 0.050
Calcium	U	1415	mg/l	5.0	8.0	19	9.2	7.0
Total Hardness as CaCO3	U	1270	mg/l	15	52	74	32	23
Arsenic (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Beryllium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	U	1450	µg/l	0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Manganese (Dissolved)	U	1450	µg/l	1.0	52	80	92	17
Nickel (Dissolved)	U	1450	µg/l	1.0	2.5	1.8	3.5	< 1.0
Lead (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Antimony (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Selenium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (Dissolved)	U	1450	µg/l	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	U	1450	µg/l	1.0	42	43	15	47
Mercury Low Level	U	1460	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dissolved Organic Carbon	U	1610	mg/l	2.0	7.8	7.9	8.8	8.5
Mineral Oil	N	1670	µg/l	10	< 10	< 10	< 10	< 10
TPH >C6-C10	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C10-C21	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C21-C40	N	1670	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total TPH >C6-C40	U	1670	µg/l	10	< 10	< 10	< 10	< 10
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10				
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10				
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10				
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10				
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10				
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10				
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10				
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10				
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0				
Aromatic TPH >C5-C7	N	1675	µg/l	0.10				
Aromatic TPH >C7-C8	N	1675	µg/l	0.10				
Aromatic TPH >C8-C10	N	1675	µg/l	0.10				

Chemtest
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Results - Water

Project: Q0083 A40 RCE

Client: Quantum Geotechnic Ltd			**Chemtest Job No.:**		19-39569	19-39569	19-39569	19-39569
Quotation No.:			**Chemtest Sample ID.:**		932751	932752	932753	932754
			Client Sample ID.:		W2	W2	W2	W2
			Sample Location:		BH13	BH14	BH15	BH16
			Sample Type:		WATER	WATER	WATER	WATER
			Top Depth (m):		1.21	1.69	5.11	3.41
			Date Sampled ($):		25-Nov-2019	25-Nov-2019	25-Nov-2019	25-Nov-2019
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Aromatic TPH >C10-C12	N	1675	µg/l	0.10				
Aromatic TPH >C12-C16	N	1675	µg/l	0.10				
Aromatic TPH >C16-C21	N	1675	µg/l	0.10				
Aromatic TPH >C21-C35	N	1675	µg/l	0.10				
Aromatic TPH >C35-C44	N	1675	µg/l	0.10				
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0				
Total Petroleum Hydrocarbons	N	1675	µg/l	10				
Benzene	U	1760	µg/l	1.0				
Toluene	U	1760	µg/l	1.0				
Ethylbenzene	U	1760	µg/l	1.0				
m & p-Xylene	U	1760	µg/l	1.0				
o-Xylene	U	1760	µg/l	1.0				
Naphthalene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	N	1800	µg/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's	N	1800	µg/l	0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols	U	1920	mg/l	0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
932742		W2	BH1	25-Nov-2019	B	Coloured Winchester 1000ml
932742		W2	BH1	25-Nov-2019	B	EPA Vial 40ml
932742		W2	BH1	25-Nov-2019	B	Plastic Bottle 1000ml
932743		W2	BH2	25-Nov-2019	B	Coloured Winchester 1000ml
932743		W2	BH2	25-Nov-2019	B	EPA Vial 40ml
932743		W2	BH2	25-Nov-2019	B	Plastic Bottle 1000ml
932744		W2	BH3	25-Nov-2019	B	Coloured Winchester 1000ml
932744		W2	BH3	25-Nov-2019	B	EPA Vial 40ml
932744		W2	BH3	25-Nov-2019	B	Plastic Bottle 1000ml
932745		W2	BH4	25-Nov-2019	B	Coloured Winchester 1000ml
932745		W2	BH4	25-Nov-2019	B	EPA Vial 40ml
932745		W2	BH4	25-Nov-2019	B	Plastic Bottle 1000ml
932746		W2	BH8	25-Nov-2019	B	Coloured Winchester 1000ml
932746		W2	BH8	25-Nov-2019	B	EPA Vial 40ml
932746		W2	BH8	25-Nov-2019	B	Plastic Bottle 1000ml
932747		W2	BH9	25-Nov-2019	B	Coloured Winchester 1000ml
932747		W2	BH9	25-Nov-2019	B	EPA Vial 40ml
932747		W2	BH9	25-Nov-2019	B	Plastic Bottle 1000ml
932748		W2	BH10	25-Nov-2019	B	Coloured Winchester 1000ml
932748		W2	BH10	25-Nov-2019	B	EPA Vial 40ml
932748		W2	BH10	25-Nov-2019	B	Plastic Bottle 1000ml

Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
932749		W2	BH11	25-Nov-2019	B	Coloured Winchester 1000ml
932749		W2	BH11	25-Nov-2019	B	EPA Vial 40ml
932749		W2	BH11	25-Nov-2019	B	Plastic Bottle 1000ml
932750		W2	BH12	25-Nov-2019	B	Coloured Winchester 1000ml
932750		W2	BH12	25-Nov-2019	B	EPA Vial 40ml
932750		W2	BH12	25-Nov-2019	B	Plastic Bottle 1000ml
932751		W2	BH13	25-Nov-2019	B	Coloured Winchester 1000ml
932751		W2	BH13	25-Nov-2019	B	EPA Vial 40ml
932751		W2	BH13	25-Nov-2019	B	Plastic Bottle 1000ml
932752		W2	BH14	25-Nov-2019	B	Coloured Winchester 1000ml
932752		W2	BH14	25-Nov-2019	B	EPA Vial 40ml
932752		W2	BH14	25-Nov-2019	B	Plastic Bottle 1000ml
932753		W2	BH15	25-Nov-2019	B	Coloured Winchester 1000ml
932753		W2	BH15	25-Nov-2019	B	EPA Vial 40ml
932753		W2	BH15	25-Nov-2019	B	Plastic Bottle 1000ml
932754		W2	BH16	25-Nov-2019	B	Coloured Winchester 1000ml
932754		W2	BH16	25-Nov-2019	B	EPA Vial 40ml
932754		W2	BH16	25-Nov-2019	B	Plastic Bottle 1000ml

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1090	Biochemical Oxygen Demand	Biochemical Oxygen demand (BOD)	Colorimetric determination of dissolved oxygen in seeded sample after 5 days incubation at 20°C.
1100	Chemical Oxygen Demand	Chemical Oxygen demand (COD)	Dichromate oxidation of organic matter in sample followed by colorimetric determination of residual Cr[VI].
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1270	Total Hardness of Waters	Total hardness	Calculation applied to calcium and magnesium results, expressed as mg l-1 CaCO3 equivalent.
1300	Cyanides & Thiocyanate in Waters	Free (or easy liberatable) Cyanide; total Cyanide; complex Cyanide; Thiocyanate	Continuous Flow Analysis.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1460	Mercury low-level in Waters by AFS	Mercury	Atomic Fluorescence Spectrometry, with collimated UV source, wavelength 253.7 nm.
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1670	Total Petroleum Hydrocarbons (TPH) in Waters by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO	Pentane extraction / GC FID detection
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-MS	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
$	This information has been supplied by the client and can affect the integrity of test data.

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

APPENDIX IX – GROUND WATER MONITORING RESULTS

GROUNDWATER MONITORING RECORD SHEET

Project Name:	A40 RCE
Project No.:	Q0083
Instruments Used:	Water Dip Meter Probe

QUANTUM GEOTECHNICAL

Date	Borehole numbers															
	BH1		BH2		BH3		BH4		BH5CP		BH6		BH7		BH8	
	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base
09/09/2019					0.54	10.06										
11/09/2019					0.57	10.06										
13/09/2019					0.56	10.10										
16/09/2019					0.51	10.10										
17/09/2019					0.48	10.09					0.71	5.20	0.58	5.00		
18/09/2019					0.47	10.08	5.68	7.45			0.70	5.20	0.58	5.01		
19/09/2019					0.56	10.09	5.47	7.45	0.85	4.49	0.67	5.14	0.47	5.07		
20/09/2019	4.53	9.40			0.35	10.15	5.00	7.45	0.45	4.49	0.64	5.14	0.67	5.00		
23/09/2019	4.24	9.48	6.54	8.90	0.32	10.09	4.81	7.45	0.78	4.49	0.67	5.16	0.61	4.99		
25/09/2019	3.74	9.39	4.48	8.90	0.47	10.00	4.72	7.45	0.23	4.47	0.58	5.17	0.54	4.89	0.37	10.06
27/09/2019	3.78	9.39	4.12	8.90	0.32	10.01	4.81	7.45	0.56	4.47	0.45	5.18	0.67	4.97	0.38	10.06
30/09/2019	3.91	9.39	4.78	8.90	0.25	10.05	4.37	7.45	0.47	4.46	0.64	5.14	0.38	4.84	0.36	10.05
02/10/2019	3.64	9.39	4.00	8.90	0.27	10.03	4.56	7.45	0.10	4.48	0.57	5.15	0.39	4.98	0.38	10.05
03/10/2019	3.65	9.39	3.99	8.90	0.18	10.06	4.58	7.45	0.00	4.49	0.52	5.18	0.47	4.95	0.34	10.04
07/10/2019	3.78	9.38	4.25	8.90	0.27	10.05	4.25	7.45	0.00	4.49	0.49	5.17	0.58	4.97	0.47	10.05
08/10/2019	3.94	9.38	4.36	8.90	0.14	10.03	4.39	7.45	0.35	4.46	0.68	5.11	0.67	4.96	0.49	10.06
09/10/2019	3.72	9.38	4.58	8.90	0.16	10.00	4.77	7.45	0.38	4.45	0.51	5.10	0.69	4.97	0.50	10.04
10/10/2019	3.54	9.38	4.12	8.84	0.11	10.02	4.58	7.45	0.17	4.46	0.58	5.14	0.63	4.96	0.47	10.05
11/10/2019	3.77	9.38	4.42	8.85	0.05	10.07	4.12	7.45	0.12	4.46	0.53	5.12	0.61	4.95	0.45	10.06
14/10/2019	3.73	9.37	4.45	8.80	0.00	10.06	4.39	7.45	0.19	4.45	0.51	5.15	0.60	4.90	0.48	10.05
15/10/2019	3.71	9.37	4.47	8.80	0.15	10.10	4.33	7.45	0.28	4.45	0.58	5.16	0.64	4.92	0.49	10.04
16/10/2019	3.75	9.37	4.58	8.85	0.00	10.01	4.35	7.45	0.18	4.44	0.41	5.13	0.63	4.97	0.43	10.05
17/10/2019	3.56	9.37	4.65	8.85	0.00	10.06	4.58	7.45	0.40	4.46	0.47	5.14	0.58	4.89	0.48	10.06
18/10/2019	3.71	9.37	4.12	8.85	0.00	10.05	4.49	7.45	0.65	4.48	0.58	5.17	0.58	4.93	0.50	10.06
25/10/2019	3.78	9.38	4.35	8.81	0.00	10.06	4.58	7.40	0.48	4.49	0.87	5.18	0.57	4.96	0.45	10.04
05/11/2019	3.89	9.37	4.41	8.81	0.02	10.05	4.61	7.37	0.62	4.46	0.45	5.19	0.54	4.96	0.47	10.02
14/11/2019	3.87	9.34	4.58	8.80	0.04	10.05	4.64	7.35	0.76	4.45	0.86	5.19	0.62	4.96	0.52	10.01
25/11/2019	4.12	9.64	4.66	8.77	0.19	9.99	4.70	7.34	Unavailable due to land owner issues Additional visit arranged						0.63	10.02
04/12/2019									0.78	4.45	0.90	5.19	0.72	4.96		

GROUNDWATER MONITORING RECORD SHEET

Project Name:	A40 RCE
Project No.:	Q0083
Instruments Used:	Water Dip Meter Probe

QUANTUM GEOTECHNICAL

Date	Borehole numbers															
	BH9		BH10		BH11		BH12		BH13		BH14		BH15		BH16	
	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base	Water Level	Base
09/09/2019															2.89	7.20
11/09/2019									0.56	9.32					3.47	7.20
13/09/2019									0.57	9.32					3.11	7.20
16/09/2019							1.25	8.60	0.42	9.32	1.02	8.50			3.17	7.20
17/09/2019							1.24	8.60	0.69	9.33	0.98	8.51			2.87	7.19
18/09/2019							1.24	8.60	0.58	9.31	0.96	8.50			2.47	7.18
19/09/2019							1.23	8.60	0.47	9.34	0.85	8.50			2.38	7.90
20/09/2019							0.90	8.60	0.28	9.31	0.88	8.50			2.99	7.18
23/09/2019							0.92	8.60	0.31	9.30	0.87	8.48			3.15	7.17
25/09/2019	0.54						0.90	8.60	0.37	9.28	0.84	8.51			3.47	7.17
27/09/2019	0.58				0.88	6.50	0.91	8.60	0.47	9.27	0.85	8.50	5.52	7.60	3.52	7.17
30/09/2019	0.25				0.68	6.50	0.92	8.61	0.42	9.31	0.82	8.50	5.49	7.59	3.41	7.18
02/10/2019	0.24		dry	16.60	1.02	6.58	0.93	8.60	0.35	9.33	0.83	8.49	5.68	5.58	3.29	7.14
03/10/2019	0.21		dry	16.60	1.45	6.59	0.91	8.61	0.12	9.32	0.81	8.47	4.87	7.60	3.48	7.15
07/10/2019	0.14		10.36	16.60	1.33	6.57	0.91	8.60	0.24	9.17	0.83	8.50	4.97	7.61	3.12	7.16
08/10/2019	0.17		10.79	16.60	0.82	6.52	0.92	8.60	0.47	9.36	0.84	8.50	4.56	7.64	2.89	7.17
09/10/2019	0.19		11.40	16.60	0.97	6.61	0.93	8.61	0.36	9.32	0.82	8.51	4.58	7.59	3.14	7.16
10/10/2019	0.00		14.30	16.60	0.93	6.61	0.94	8.60	0.25	9.30	0.83	8.49	4.49	7.61	3.49	7.17
11/10/2019	0.00		13.40	16.60	0.91	6.60	0.93	8.60	0.36	9.34	0.84	8.51	4.51	7.64	2.93	7.16
14/10/2019	0.00		9.10	16.60	0.94	6.60	0.92	8.60	0.34	9.30	0.82	8.50	4.59	7.60	3.13	7.15
15/10/2019	0.00		9.99	16.60	0.93	6.60	0.94	8.64	0.27	9.30	0.83	8.49	4.58	7.58	3.45	7.15
16/10/2019	0.00		9.47	16.60	0.82	6.61	0.93	8.60	0.00	9.29	0.85	8.50	4.53	7.60	3.27	7.14
17/10/2019	0.00		10.84	16.60	0.97	6.60	0.92	8.59	0.12	9.27	0.82	8.50	4.57	7.59	2.86	7.16
18/10/2019	0.00		9.12	16.60	0.92	6.61	0.91	8.60	0.00	9.30	0.81	8.49	4.59	7.62	2.58	7.15
25/10/2019	0.00		9.11	16.60	1.29	6.57	0.91	8.58	0.21	9.30	0.81	8.50	4.58	7.62	3.11	7.15
05/11/2019	0.00		9.10	16.60	0.94	6.60	0.92	8.60	0.34	9.30	0.82	8.50	4.59	7.60	3.13	7.15
14/11/2019	0.00		9.53	16.59	1.55	6.58	1.55	8.54	1.16	9.30	1.67	8.48	4.65	7.61	2.61	7.14
25/11/2019	0.00	3.38	9.55	16.57	1.63	6.58	1.72.	8.49	1.21	9.31	1.69	8.57	5.11	7.60	3.41	9.60

Welsh Government

A40 Penblewin to Redstone Cross Improvements

Ground Investigation Report

A40PRC-ARP-HGT-M02-RP-C-0006

P02 | S4

09/04/20

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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1 The Project

1.1 Context

1.1.1 In February 2017 the Welsh Government appointed Carillion, with Arup and RML (the 'Carillion Team') as their technical and environmental advisors, to develop the design of the proposed A40 Llanddewi Velfrey to Penblewin Improvements up to the publication of draft Orders.

1.1.2 Carillion entered liquidation in January 2018. The Welsh Government subsequently appointed Arup, supported by RML, to continue the development of the design up to the publication of draft Orders and to support the Welsh Government through the Statutory process.

1.1.3 Further to this, Arup, supported by RML were instructed by Welsh Government in January 2019, to progress all works necessary to facilitate design development, environmental impact assessment and publication of draft Orders for a WS2+1 solution between Penblewin Roundabout and Redstone Cross.

1.2 Project history

1.2.1 In December 2004 the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvements would use the 2+1 configuration allowing overtaking on the two-lane direction, with overtaking prohibited in the one-lane direction and would be delivered in the following phases:

a) A40 Penblewin - Slebech Park

b) A40 Llanddewi Velfrey - Penblewin.

1.2.2 The first of these projects, Penblewin - Slebech Park, was completed in March 2011.

1.2.3 In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

"Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements."

1.2.4 On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary:

"In terms of transport links, I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey."

1.2.5 In June 2015, in a written statement on the A40 Improvement Study, the Minister noted: *"It is my intention to progress delivery of the A40 Llanddewi Velfrey to Penblewin scheme as soon as possible…"*

1.3 The problems

1.3.1 The following problems have been identified in collaboration with the A40 Llanddewi Velfrey to Penblewin Improvements Scheme and early public consultation:

a) The A40 mainline and Redstone Cross Junction is substandard

b) Limited overtaking opportunities lead to poor journey time reliability and driver frustration.

c) Adverse road safety conditions including poor visibility and geometry at Redstone Cross Junction

d) Perceived adverse safety conditions at Redstone Cross Junction

e) Occasional convoys of heavy goods vehicles from the ferry ports and slow-moving agricultural vehicles contribute to periods of platooning and journey time unreliability, which is exacerbated with limited overtaking opportunities.

f) Seasonal spikes in traffic volumes along the A40 especially during the summer months leads to slow-moving traffic causing journey time unreliability, which is exacerbated with limited overtaking opportunities.

g) There are many side road junctions and direct accesses to properties and agricultural fields off the A40, which contributes to operational problems along the road.

h) A mix of traffic types using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents.

i) A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.

1.4 Scheme objectives

1.4.1 A number of strategic transport planning objectives have been developed iteratively during the previous A40 Improvement Schemes, and specifically the A40 Llanddewi Velfrey to Penblewin. During the early stages of the A40 Penblewin to Redstone Cross Improvements Key Stage 3, these objectives were refreshed to consider both the strategic and local transport planning aspects for the Redstone Cross Area. The scheme objectives are:

O1 To enhance network resilience and improve accessibility along the east-west transport corridor to key employment, community and tourism destinations.

O2 To improve prosperity and provide better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard, Milford Haven and Pembroke Dock.

O3 To reduce community severance and provide health and amenity benefits.

O4 To improve the Redstone Cross Junction safety (and perceived safety) and reduce the number and severity of A40 mainline collisions.

O5 To promote active travel by cycling, horse riding and walking to provide opportunities for healthy lifestyles.

O6 To deliver a scheme that promotes social inclusion and integrates with the local transport network to better connect local communities to key transport hubs.

O7 Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.

O8 Give due consideration to the impact of transport on the environment and provide enhancement when practicable.

1.5 Purpose of this report

1.5.1 This report summarises and interprets the available information gathered about the ground conditions along the A40 Penblewin to Redstone Cross Improvements scheme.

1.6 Report structure

1.6.1 After this section, the report comprises of the following chapters:

a) Section 2: Scope and objectives
b) Section 3: Existing information
c) Section 4: Field and laboratory studies
d) Section 5: Ground summary
e) Section 6: Geotechnical risk register
f) Section 7: Engineering assessment

2 Scope and objectives

2.1 Scope and objective of the report

2.1.1 The geotechnical aspects of design will be undertaken in accordance with DMRB standard CD 622 [1]. The objective is to identify and suitably manage the geotechnical risks associated with the project.

2.1.2 This Ground Investigation Report (GIR) presents available geotechnical information including details of geological features and relevant desk study data. Factual reporting of the ground investigation undertaken has been completed by a specialist ground investigation contractor and contains details of all works and testing carried out [2]. This GIR includes an assessment of the information and states the assumptions made during this interpretation of the results.

2.1.3 This report should be read alongside the following Drawings:

Drawing 1 – Site Location Plan (A40PRC-ARP-EGT-SWI-DR-LE-0001);

Drawing 2 – Geotechnical Features and Constraints Plan (A40PRC-ARP-EGT-SWI-DR-LE-0002);

Drawing 3 – Ground Investigation Location Plan (West Section) (A40PRC-ARP-EGT-SWI-DR-LE-0003);

Drawing 4 – Ground Investigation Location Plan (East Section) (A40PRC-ARP-EGT-SWI-DR-LE-0004).

2.2 Geotechnical category

2.2.1 The supplementary Preliminary Sources Study Report (PSSR) undertaken by Arup in 2017 [3] classified the project as Geotechnical Category 2 in accordance with the guidelines stipulated in HD22/08.

2.2.2 HD22/08 has been superseded in August 2019 by CD 622 and as such the geotechnical classification has been reviewed in Chapter 7 based on the findings of this GIR with respect to the ground conditions encountered and the proposed engineering across the scheme.

2.3 Other relevant information

2.3.1 The supplementary Preliminary Sources Study Report (PSSR) [3] has been reviewed as part of this report. Since completion of the PSSR, the proposed scheme has been extended a further 600m to the west and will now extend from the existing Penblewin Roundabout and tie back into the existing A40 approximately 600m to the west of the Redstone Cross Junction, this new alignment is shown on Drawing 1.

2.3.2 This GIR presents additional information obtained to cover the extended route and summarises the main findings of the PSSR.

2.3.3 Concurrent with this scheme, the Welsh Government are proceeding with a bypass for the village of Llanddewi Velfrey to the immediate east of Penblewin Roundabout. A GIR has been produced by Arup in 2017 [4] to cover the scheme and has been reviewed as part of this GIR.

3 Existing information

3.1 General

3.1.1 Since completion of the supplementary PSSR in 2017, the proposed scheme design has been developed and has been extended a further 600m to the west and will now extend from the existing Penblewin Roundabout and tie back into the existing A40 approximately 600m to the west of the Redstone Cross Junction. Therefore, the sources of information which were reviewed for the PSSR have been revised in line with this updated alignment and are presented below.

3.1.2 A features and constraint plan has been prepared for the scheme (A40PRC-ARP-EGT-SWI-DR-LE-0002). The features are identified on the plan using a notation system. The notation of any features identified in the text below is provided in brackets and summarised in Appendix A (e.g. WS1, LB2).

3.2 Topographical maps

3.2.1 The topography along the Scheme has been informed by a combination of LiDAR (digital terrain) data from the Lle LiDAR Composite Dataset (Natural Resources Wales database accessed in February 2020) and a topographic survey (dated 07/11/2019).

3.2.2 The aim of the topographical survey was to verify the Lidar survey at key locations along the scheme, such as along watercourses and at tie-in points. Where differences in ground level are apparent between the two sets of survey, the information from the topographic survey has been adopted. As part of the detailed design a site specific topography survey is recommended.

3.3 Historical maps

3.3.1 The PSSR for the scheme contains a review of the historical mapping for the area, a revised summary of this is provided in Table 1 accounting for changes to the alignment since 2017.

Table 1 Summary of historical development [5]

Historical map (Date)	Description of the development in the vicinity of the proposed alignment
Pembrokeshire / Carmarthenshire 1:10,560 (1888)	The A40 is shown in its current alignment with buildings along the highway at Blackmoor Hill (noted as *"Cilrath-fâch cottages"*) and Redstone Cross Junction (noted as *"Blaen-Marlais"*(LB2) to the south and *"Redstone Farm"* to the north). A spring is noted to the south of the buildings at Blackmoor Hill (WS3). A well immediately to the south-west of Redstone Cross Junction is indicated (WS2), with a watercourse issuing near this. Enclosed fields (assumed to be pasture) are shown with the boundaries in the present-day locations. Heathland / rough grassland is shown to the south and the east of the Blackmoor Hill settlement, along the proposed route of the A40. Several quarries and old quarries (HF3) are noted on the maps, particularly north of the alignment, in the vicinity of Cilrath Wood and Sodstone House (LB1). However, none are noted on the existing or proposed alignment of the A40 highway.
Pembrokeshire / Carmarthenshire 1:10,560 (1907)	No major change. The extent of heathland / rough grassland is shown to be slightly greater than shown in the 1888 maps. A reservoir (HF4) is now shown to be located immediately east of Sodstone House, in the vicinity of springs and old quarries.
Pembrokeshire / Carmarthenshire 1:10,560 (1953)	No major changes. A Spring (WS4) is noted near Sodstone House, this may be a source for the reservoir (HF4) previously mentioned.
Ordnance Survey 1:10,000 (1964)	The reservoir (HF4) which was shown immediately east of Sodstone House is no longer shown on the map. A former marsh (HF2) is noted approximately 250m north of Blackmoor Farm (this feature is not shown on Drawing 2).
Ordnance Survey 1:10,000 (1970)	A forge is noted immediately to the south-west of Redstone Cross Junction (HF5).
Ordnance Survey 1:10,000 (1974)	No major changes.

Historical map (Date)	Description of the development in the vicinity of the proposed alignment
Raster Mapping 1:10,000 (2006)	No major changes. Watercourses (mainly drains) are shown on the map. One crosses the proposed alignment at Blackmoor Hill Farm and another is shown further south however this does not cross the alignment, these are shown as watercourses on Drawing 2. The spring (WS3) to the south of Blackmoor Hill Farm is no longer shown. Development associated with Narberth is shown over 1km south of the proposed and existing alignments. A small body of water (assumed to be a pond) is shown immediately north of the proposed alignment (WS5), east of where it joins the existing alignment at Redstone Junction.
Vector Map Local 1:10,00 (2015)	No major changes.

3.4 Geological maps and memoirs

3.4.1 A review of the 1:50,000 [6] and 1:10,560 [7] geological maps and British Geological Survey (BGS) 50k geology dataset [8] has been undertaken. A memoir [9] produced by the BGS for the geological survey sheet has also been reviewed alongside these geological sources.

3.4.2 Drawing 2 contains an extract of the BGS 50k geology dataset and presents the geological dip for the various strata as reported on the 1:50,000 and 1:10,560 geological plans.

3.4.3 A summary of the anticipated ground conditions underlying the site is presented below.

Superficial deposits

Made Ground

3.4.4 Although the site history shows little development, there is potential for Made Ground to be encountered associated with the construction of the existing highway. In addition, Made Ground may be encountered in discrete locations across the site associated with the sources identified in Section 3.10.10.

Glacial Till (0+750 to 1+250)

3.4.5 The central area of the alignment is shown on the geological maps to be underlain by Glacial Till, however no information pertaining to the composition and thickness of these deposits was available.

3.4.6 During a site visit, it was observed by an Arup Engineering Geologist that the landscape of southern Pembrokeshire is not indicated to be affected by glacial processes. This can be seen in the broad plateau areas with margins deeply incised by minor valleys, uplift and dissection of a late Neogene marine erosion platform. In addition to this, the BRITICE Project [10] (a compilation of UK Quaternary data) reports that the central and southern areas of Pembrokeshire were not glaciated. As such, it is likely that the areas of superficial deposits recorded as Glacial Till, are more likely to be periglacial head deposits.

3.4.7 During this site walkover, it was observed that to the east of Redstone Cross the existing highway is formed in a shallow cutting. This may be the result of localised removal of superficial deposits for the historical formation of a ‘sunken track’. Inspection of the slope was not practical due to the hazardous traffic conditions and heavy vegetation.

Alluvial Deposits

3.4.8 No alluvial deposits are indicated however due to the presence of watercourses across the site localised areas may be encountered.

Solid geology

3.4.9 The sequence of solid geology underlying the scheme is presented on Drawing 2 and is as follows (youngest strata on top):

a) Haverford Beds Formation
b) Slade and Redhill Formation
c) Dicranograptus Beds Formation
d) Llandeilo Limestone Formation

3.4.10 The predicted surface extent of the above strata suggests that the strata have been folded (anticline fold) and then have been eroded so that the oldest strata (Llandeilo Limestone Formation) are located towards the centre of the scheme and the formations young to the east and west away from the fold axis. The proposed alignment is shown to cross two

faults: one at 1+690 which bisects the alignment at approximately 80 degrees and one at 1+040 which bisects at around 45 degrees. The dip of the underlying bedrock is shown to vary considerably in both direction and dip angle which suggests the underlying bedrock is folded as well as faulted across the site. A third fault is shown to be present approximately 50m south of the proposed alignment and runs in an east-west direction. These linear features are also presented in Drawing 2.

3.4.11 A valley feature can be observed at approximately Ch. 1+400, that is between the Dicranograptus Beds Formation and Slade and Redhill Formation. Some Hill Creep terraces are noted at the top of the slope to the north. In addition to this, a possible outcrop of the Dicranograptus Beds Formation was noted which seemed to be steeply dipping, this suggests that the boundary between the formations could be faulted forming a weak zone picked out by the erosion that has led to the present-day watercourse.

Haverford Beds Formation (0+000 to 0+450)

3.4.12 The area to the west of Redstone Cross Junction is underlain by the Haverford Beds Formation. In particular the Cethings Sandstone and Gasworks Mudstones sub-formations. The Haverford Beds Formation is also shown to be present immediately to the east of Penblewin Roundabout.

3.4.13 The Cethings Sandstone stratum is reported to comprise fine-grained grey sandstone and is underlain by soft blue-black shales.

3.4.14 The Gasworks Mudstones is reported to be thin-bedded shaly green mudstone with occasional sandstone-bands up to six inches thick, these are in turn followed by massive sandy mudstones often showing spheroidal structures [9]. Bedding dips of 28 degrees towards the south-west are reported.

3.4.15 This formation is thought to have been encountered during the initial ground investigation undertaken for Llanddewi Velfrey. It was described as *"weathered conglomerate recovered as firm orange brown very sandy silt/clay with many fine to coarse sub-angular to sub-rounded gravel of sandstone and mudstone"* [11].

Slade and Redhill Formation (0+450 to 0+720 and 1+400 to 1+780)

3.4.16 The geology beneath the majority of the scheme is the Slade and Redhill

Formation. It is reported to be part of the Bala Series and consist of *"blue-grey mudstones, with frequent thin bands of brown or grey micaceous sandstone and highly calcareous layers weathering to a brown sandy rottenstone "* [9].

3.4.17 The geological memoir notes that the Slade and Redhill Formation is exposed in an almost continuous section along Blackmoor Hill and that the calcareous base is seen in the well that supplies the cottages on Blackmoor Hill. In addition, it is noted that at Penblewin *"about 360 feet of Slade and Redhill Beds are present of which perhaps 300 feet are referable to the Slade stage."* However, during site walkovers, these features were not identified and no access to the well was possible.

3.4.18 The geological map [6] indicates bedding dip towards the north ranging from 23 to 35 degrees between the faults. To the west of these faults, the dip angle is shown to be 10 degrees to the west.

3.4.19 Frost shattered outcrops of the Slade and Redhill Formation were noted in an eroded track to the north of the existing A40.

Dicranograptus Beds Formation (0+720 to 1+400)

3.4.20 A central area of the alignment to the east of Redstone Cross is underlain by the Dicranograptus Beds Formation [6].

3.4.21 The Dicranograptus Beds Formation is reported to be approximately 140m (470ft) thick and described as *"somewhat rubbly dark-grey pyritous shales in their lower part but towards their upper limit become more evenly bedded"* [9]. The formation is formed from four subdivisions which are generally sandy or flaggy shales with bands of occasional limestone or mudstone. Anecdotal evidence suggest that this formation is anticipated to be highly pyritic and anoxic (BGS Cardiff).

Llandeilo Limestone Formation (0+900 to 1+075)

3.4.22 A small area of the alignment to the east of Redstone Cross between chainage 0+900 and 1+075 is noted to be underlain by the Llandeilo Limestone Formation. This is reported to consist of only Llandeilo Flags [6]. Llandeilo Flags is reported to comprise of *"fossiliferous sandy calcareous flags"* which is followed by *"somewhat massive dark-blue sparsely-fossiliferous limestones weathering to a yellowish-brown rottenstone."* [9].

3.5 Aerial photographs

3.5.1 The aerial photographs available at the Welsh Government Aerial Photography Unit covering the period from 1946 to 2013 were reviewed by a geotechnical engineer in 2017. These underwent a further review in 2019 and covered the period of 1946 to 2016.

3.5.2 These photographs provided no indication of any additional features to those identified from the review of the historic plans.

3.5.3 The reservoir (HF4), refer to section 3.3, located to the north of Redstone Cross Junction is not shown in the 1946 photographs. It is noted that this is contrary to the historical OS maps which show it to be present 1907 to 1964.

3.5.4 The aerial photographs available at the Lle online database [12] and Cambridge air photos [13] were also reviewed, these date from 1945 to the present day. These also provided no further indication of any features to those previously identified.

3.6 Records of mines and mineral deposits

3.6.1 Records of mines and mineral deposits have been reviewed from the Review of Mining Instability in Great Britain report [14] for metalliferous mining (non-ferrous), rock mining, coal mining (and associated minerals), iron mining (non-coalfield) and evaporite mining, and from review of the Coal Authority online viewer [15] in relation to coal mining. These reviews identified no workings in the nearby area.

3.6.2 Two BGS recorded mineral sites [5] have been identified to the south of the proposed alignment. These are both noted to be opencast mines. Rushacre Farm (MS1) is noted to be active and mines the Haverford Beds Formation for clay and shale. The Green (MS2) is noted to have ceased, this mined the Slade and Redhill Formation for clay and shale. Areas of potentially infilled land (non-water) are also associated with these mineral sites, these are all dated to 1974 and have unknown uses.

3.6.3 A historic quarry (HF3) has also been identified, this location also has a pond noted nearby (WS1) which may be associated. An area noted as potentially infilled land (PIL1) is recorded [5] to the west of Blackmoor Hill farm. This is recorded to be “unknown filled ground” and could be associated with a pit or quarry. Further areas of potentially infilled land

(PIL2) are shown in Figure 2.

3.7 Archaeological and historical investigation

3.7.1 The Cof Cymru National Historic Assets of Wales online viewer (created by Cadw) [16] records the presence of a scheduled monument (noted as tumuli on the OS plan). The available report from Cadw [17] describes these as the Redstone Cross Round Barrows (HF1), noting their probable creation during the Bronze Age. These structures are likely to have been used as burial grounds, as such the report notes that both intact ritual and burial deposits, together with environmental and structural evidence could be present.

3.7.2 The online viewer also indicates that Blaen Marlais (LB2), located approximately 50m south of the proposed alignment, is a listed building. The location of this is shown on Drawing 2.

3.7.3 A geophysical survey was undertaken for archaeological purposes by RML (Richards, Moorehead and Laing Ltd). This was limited to an area to the east of Redstone Cross Junction.

3.8 Existing ground investigations

3.8.1 No ground investigations have been carried out specifically for the scheme prior to the 2019 investigation.

3.8.2 The BGS online datasets [8] did not indicate any existing exploratory hole records within 500m. However as discussed in Section 2.3.3 a ground investigation has been undertaken as part of the Llanddewi Velfrey to Penblewin section of the scheme, a GIR has been produced by Arup [4].

3.9 Consultation with statutory bodies and agents

3.9.1 The Welsh Government IRIS (Integrated Roads Information System) database has been reviewed [18]. No relevant observations have been identified for the proposed scheme.

3.9.2 The scheme is subject to an Environmental Statement, for this, regulators such as Natural Resources Wales and Pembrokeshire County Council have been engaged through the planning process.

3.10 Other relevant information

Hydrology and hydrogeology

3.10.1 The PSSR [3] provides a review of the hydrology and hydrogeological features of the scheme, these are also shown on Drawing 2. This review identified watercourses and water sources within 150m of the proposed alignment, these are presented below in Table 2.

Table 2 Summary of known watercourses within 150m buffer of the proposed alignment (GW = Groundwater, SW = Surface Water) [19]

Feature type		Chainage	Approximate distance from proposed main alignment	Assumed Base flow
Headwaters of unnamed tributary of Longford Brook (WS6)		1+590	130m N	GW/SW
Headwaters of unnamed tributaries of Afon Marlais	Spring(WS3)	1+150	120m N	GW
	Collects(WS7)	0+800	130m S	GW/SW
Headwaters of unnamed tributaries of Narbeth Brook	Issues (WS8)	0+420	35m S	GW
	Spring (WS9)	0+480	40m N	GW/SW
Well (WS2)		0+480	40m N	GW
Pond (WS10)		1+779	75m SE	GW
Pond (WS11)		0+680	113m S	GW
Pond (WS5)		0+700	40m N	GW

3.10.2 The NRW flood record [20] shows a low risk of flooding from rivers in the immediate vicinity of the watercourse crossing the site.

3.10.3 The bedrock underlying the site is classified predominately as Secondary B aquifers, apart from the Llandeilo Flags Formation which is classified as a Secondary A aquifer [5]. Glacial Till is shown to be an unproductive stratum.

Unexploded Ordnance (UXO)

3.10.4 A preliminary UXO risk assessment has been undertaken in accordance with CIRIA C681 [21] and is included below.

3.10.5 The potential for aerial delivered ordnance has been assessed for the

scheme and after a review of the available historical and OS data no evidence of potential World War two targets was found, and no evidence of military use has been identified.

3.10.6 The published geological maps show limited areas of recorded superficial deposits across the scheme. The potential for aerial delivered ordnance to have landed in the scheme and failed to detonate on impact is considered to be low.

3.10.7 As discussed previously, no significant commercial development of the scheme has occurred since World War Two. However, the land has been maintained through its use as agricultural land.

3.10.8 The proposed development of the scheme includes large excavations and ground investigation over an extended area which will increase the risk of encountering unexploded ordnance.

3.10.9 As the scheme is rural with no large areas of soft ground and no history of World War Two bombing, a detailed assessment is not considered to be required for either ground investigation or design of permanent works. The Contractor should undertake their own assessment in advance of any works on site.

Contaminated land

3.10.10 A review of the information presented in the PSSR [3] identifies the following potential sources of contamination:

a) Activities associated with Redstone Forge Garage (HF5) located at approximately Ch. 0+550 on Redstone Road. These activities may have resulted in accidental spillages or leakages which may have impacted the soils and groundwater. The site walkover noted this service to have ceased.

b) Localised spillages from farming machinery, fuel storage or waste storage.

c) Made Ground associated with agricultural activities e.g. access tracks, infilled land

d) Made Ground associated with the construction of the existing A40 although this is unlikely to pose a significant risk.

3.10.11 In addition, a pollution incident occurred during the ground investigation during drilling works at borehole BH09. This involved a breakage in the hydraulic pump attached to site machinery resulting in

4.5 litres of fuel spillage at chainage 1+320.

Ground Hazard

3.10.12 The Landmark Envirocheck report [5] also notes three ground hazards (GH1, GH2 and GH3). These are noted to be potential for landslide, shrinking or swelling clays and running sands respectively. The site walkovers undertaken have observed these locations and noted no evidence of hazards.

3.11 Site reconnaissance

3.11.1 Offline and online walkovers have been undertaken as part of the PSSR development and GI planning.

3.11.2 An Arup engineer was present on site full time to observe the fieldwork component of the ground investigation works.

4 Field and laboratory studies

4.1 Geomorphological / geological mapping

4.1.1 No geomorphological or geological mapping has been undertaken on the scheme however, as noted in Section 3.4, a site walkover was conducted by an Arup Engineering Geologist.

4.2 Ground investigations

4.2.1 A ground investigation was specified and undertaken in 2019. The aim of the ground investigation was to determine the ground conditions and obtain geotechnical, groundwater, geo-environmental and geochemical information for the purposes of preliminary design, to establish a baseline for the ES and to reduce the uncertainty associated with the ground and proposed form of construction ahead of tender.

4.3 Description of fieldwork

4.3.1 The ground investigation was undertaken by Quantum Geotechnic Ltd between 2nd September and 4th December 2019 and supervised by Arup. It included the following:

a) Boreholes undertaken along the alignment within the proposed embankments and cuttings locations to identify the stratigraphy, undertake in-situ testing and obtain soil samples for strength and compressibility testing for assessment of stability and settlement.

b) Trial pits to provide information on the potential variation in shallow ground conditions and to obtain soil samples for earthworks testing.

c) Dynamic samples to confirm approximate extents of potential soft ground that may be present.

d) Soakaway tests carried out in the locations of two of the proposed attenuation ponds to inform infiltration of the natural strata. Not all ponds were targeted as the drainage design was under development during specification of the ground investigation.

e) California Bearing Ratio (CBR) tests undertaken at trial pit locations to inform the design at at-grade locations.

f) Installation of standpipes in all boreholes to monitor groundwater levels.

4.3.2 The locations of all completed exploratory holes are shown on Drawing

3 and Drawing 4.

4.3.3 Due to programming constraints, RCE-BH05 was undertaken as two separate cable percussion (BH05CP) and rotary core holes (BH05ROT). These were undertaken adjacent to each other and therefore for the purposes of this report will be referred to as RCE-BH05.

4.3.4 Due to land access constraints, the following works were cancelled: RCE-TP16 and TP17; and RCE-DS11 to 15.

4.4 Results of in-situ tests

4.4.1 In-situ CBR tests were undertaken as part of the ground investigation in seven of the trial pits (RCETP01, RCETP02, RCETP05, RCETP06, RCETP13, RCETP18 and RCETP19). The results of the testing are presented in the Factual Report [2] and discussed in Section 5 of this GIR.

4.5 Drainage studies

4.5.1 In-situ soakaway test were undertaken as part of the ground investigation in three trial pits (RCESA12, RCETP01 and RCETP12). The results of the testing are presented in the Factual Report [2] and discussed in Section 5 of this GIR.

4.6 Geophysical surveys

4.6.1 As stated in Section 3.7, a geophysical survey was undertaken for archaeological purposes by RML. No further geophysical surveys have been undertaken for the scheme.

4.7 Laboratory investigation

4.7.1 Soil and water samples were obtained from the exploratory holes for laboratory testing. In addition water was sampled from nearby surface water features. Testing has been undertaken on these samples to inform items including earthworks stability, the contaminated land baseline for the ES and the requirement for any specific design or mitigation measures.

4.8 Description of tests

Geotechnical laboratory tests

4.8.1 Geotechnical testing was undertaken to determine material parameters to be used for the design, this included tests such as the Atterberg tests, particle size distribution, compaction, triaxial and shear box tests. These will be utilised to derive a suitable ground model of the scheme.

Geo-environmental laboratory tests

4.8.2 Geo-environmental laboratory testing was undertaken in order to prepare risk assessments detailing the management of potentially contaminative materials, as well as informing human health and controlled waters risk assessments. The ground investigation obtained a series of chemical data, consisting of the following:

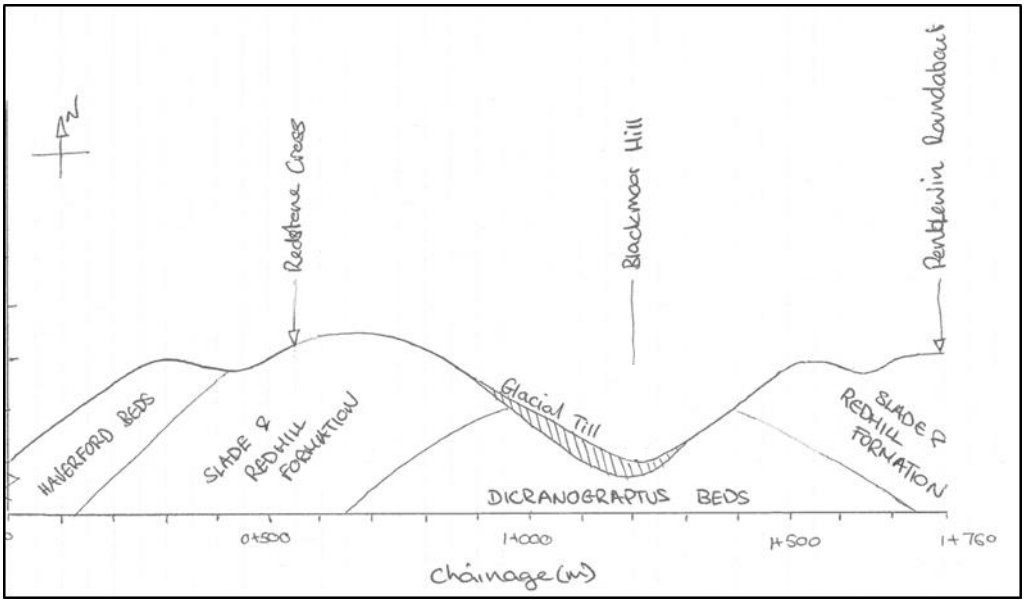
a) Soil samples to inform human health risk assessments and material suitability for reuse (PAHs, heavy metals, BTEX and Total Petroleum Hydrocarbons).
b) Soil leachability testing to inform controlled waters risk assessment and soil quality assessment (metals, general inorganics and phenols).
c) Surface and groundwater chemical testing to inform controlled waters risk assessments (general inorganics, metals, Total Petroleum Hydrocarbons, PAHs, BTEX and phenols).
d) Bioavailability parameters (i.e. pH, Ca and DOC) were also obtained at the different controlled waters receptors; to calculate the concentrations of bioavailable metals.

5 Ground summary

5.1 Introduction

5.1.1 The ground conditions underlying the scheme have been interpreted in line with the anticipated geology presented in Section 3.4 and on Drawing 2.

5.1.2 A conceptual geological sketch is shown below to highlight the various geological formations and superficial deposits along the length of the proposed scheme as identified in Section 3.4.



Sketch 1 Indicative conceptual geological model.

5.1.3 Based on the results of the ground investigation across the site, the ground conditions typically comprise topsoil overlying weathered bedrock that in turn overlies intact bedrock. For the purpose of this report, it is proposed to consider the bedrock as weathered where it has been logged with soil descriptors and as intact where it has been logged as a rock. The ground conditions encountered are presented on a series of long sections and cross-sections at each earthworks zone. These are contained within Figures 1 to 10.

5.1.4 The scheme has been divided up into different earthworks zones for ease of assessing the engineering properties. Ground models have been derived for each zone and are presented below after which descriptions of the strata encountered are presented and interpreted engineering properties based on the material descriptions, in-situ testing and

laboratory testing.

5.2 Summary of ground conditions

5.2.1 A summary of the encountered geology and groundwater during the ground investigation is presented in Table 3. This has been separated by earthworks zone that gives the chainage extent, description of the earthworks, other scheme features and relevant exploratory holes for each zone.

5.2.2 Where earthworks zones overlap geological strata, the exploratory holes for the entire strata have been evaluated and presented in Table 3 below. As part of the Geotechnical Design Report, an evaluation specifically for each earthwork will need to be conducted and compared against the site wide evaluation presented below.

Table 3 Summary of ground conditions by earthwork zone

Earthworks Zone	Chainage (m)	Exploratory holes	Description of earthwork	Summary of ground conditions			
				Strata	**Typical description**	**Depth to top (m)**	**Thickness (m)**
Cutting 1 (**Figure 4**)	0+000 to 0+350	RCE-TP01 RCE-TP02 RCE-TP03 RCE-TP04 RCE-BH01	Mainline in side long cut (maximum height 3.0m at Ch0+260) Attenuation ponds A and C located in cut	Topsoil	Sandy slightly gravelly clay	0	0.25-0.4
				Weathered Haverford Beds	Brown clayey slightly sandy gravel of sandstone and mudstone	0.25-0.4	0.7-2.9
				Intact Haverford Beds	Light grey/brown strong fractured sandstone	1	-
				Groundwater struck at 1m depth. Maximum monitored groundwater level at 3.6m depth (response zone at 9m depth).			
Embankment 1 (**Figure 5**)	0+350 to 0+500	RCE-BH02 RCE-BH15 RCE-DS01 RCE-DS02 RCE-DS05	Mainline on embankment <2m high up to Ch0+400. After Ch0+400 ground level falls across the embankment towards existing valley resulting in embankment fill up to 10m high (0+430). After Ch0+450 ground level becomes flat	Topsoil	Sandy slightly gravelly clay	0	0.25-0.4
				Weathered Slade and Redhill Formation	Encountered as either: 1. Soft to firm brown orange slightly silty slightly sandy gravelly clay 2.Brown clayey sandy gravel of mudstone	0.25-0.4	0.25-0.7
				Intact Slade and Redhill Formation	Very weak to weak brown grey to dark grey slightly to moderately weathered mudstone	0.7-2.3	-
				Groundwater strikes at 6.7 and 12.5m depth. Maximum monitored groundwater level of 4m depth (response zone at 9.5m depth)			
Cutting 2 (**Figure 6**)	0+500 to 0+740	RCE-TP05 RCE-TP06 RCE-TP07 RCE-TP18 RCE-BH03 RCE-BH04 RCE-BH12 RCE-BH13 RCE-BH14	Mainline in relatively symmetrical cut up to 6m high (0+600) Redstone Overbridge (0+572) with approach embankment (up to 4m) located at crest of cut	As per embankment 1 Groundwater strikes at 4 to 9m depth. Maximum monitored groundwater levels of <1m to 4m depth (response zones 6 to 8m depth)			

Earthworks Zone	Chainage (m)	Exploratory holes	Description of earthwork	Summary of ground conditions			
				Strata	**Typical description**	**Depth to top (m)**	**Thickness (m)**
Embankment 2a (**Figure 7**)	0+740 to 1+250	RCE-TP08 RCE-TP09 RCE-TP10 RCE-BH05 RCE-BH06 RCE-BH07 RCE-DS06a RCE-DS06b RCE-DS07 RCE-DS08 RCE-DS09 RCE-DS10	Mainline on relatively symmetrical embankment up to 4.5m high (0+910) Attenuation Pond D north of the scheme at Ch0+800	Topsoil	Brown to dark brown slightly sandy gravelly clay	0	0.1-0.4
				Glacial Deposits	Firm to very stiff brown sandy gravelly clay with gravel of mudstone and sandstone. (Soft material encountered in RCETP10)	0.2-0.4	0.5-8.5 (generally 5m)
				Weathered Dicranograptus Formation	Orange brown clayey sandy gravel	0.5-5.3	0.1-4.7
				Intact Dicranograptus Formation	Very weak to moderately weak black slightly weathered siltstone/mudstone	2.5-10	-
				Weathered Llandeilo Limestone Formation	Orange brown clayey sandy gravel	2.3-4.5	4.8
				Intact Llandeilo Limestone Formation	Moderately weak dark grey siltstone with occasional sandy beds	9.8	-
				Llandeilo Limestone Formation encountered in two exploratory holes (RCEBH06 and RCETP09) Groundwater strikes at 4 to 5.5m depth. Maximum monitored groundwater levels of <1m depth (response zones around 4m depth)			
Embankment 2b (**Figure 8**)	1+250 to 1+490	RCE-TP11 RCE-TP12 RCE-TP13 RCE-BH08 RCE-BH09	Mainline on embankment up to 10m high (1+360) filling an existing drainage valley	As per Embankment 2a RCE-TP13 is located at the eastern end of the embankment and encountered material consistent with the Slade and Redhill Formation, this correlates to the geological maps. Groundwater strikes at 1.6 to 8.5m depth. Maximum monitored groundwater levels of <1m depth (response zones at 2m and 9m depths)			

Earthworks Zone	Chainage (m)	Exploratory holes	Description of earthwork	Summary of ground conditions			
				Strata	**Typical description**	**Depth to top (m)**	**Thickness (m)**
Cutting 3 (**Figure 9**)	1+490 to 1+780	RCE-TP14 RCE-TP15 RCE-BH10 RCE-BH11	Mainline in asymmetrical cut up to 6m high on northern face (1+560) Main line at grade approaching Penblewin Roundabout Attenuation Pond E	Topsoil	Brown sandy slightly gravelly clay	0	0.2-0.4
				Weathered Slade and Redhill Formation	Orange brown to pale brown clayey slightly sandy gravel of mudstone	0.2-0.4	0.5-1.5
				Intact Slade and Redhill Formation	Weak to moderately strong brown and dark grey siltstone and mudstone. Heavily fractured in places	0.2-2.2	-
				Groundwater strike at 6m depth (and not struck in RCEBH10). Maximum monitored groundwater levels of <1m depth (response zones at 5m) (RCEBH10 monitored maximum groundwater level of 9m depth (response zones at 15m depth) – initially dry but ingress after 5 days)			
B4313 tie in to A40 (**Figure 10**)	0+000 to 0+226 (side road chainage)	RCE-TP19 RCE-BH15 RCE-BH16 RCE-DS03 RCE-DS04	Side road on side long embankment filling existing valley feature up to 16m high (0+040)	Topsoil	Brown slightly sandy gravelly clay	0	0.25-0.6
				Weathered Slade and Redhill Formation	Brown clayey sandy gravel of mudstone	0.3-0.6	0.1-0.7
				Intact Slade and Redhill Formation	Weak to very weak brown and grey mudstone. Heavily fractured	0.25-1	-
				Groundwater strike at 6.7m and 9.5m depth. Maximum monitored groundwater levels of 2.4m to 4.5m depths (response zones at 7.5m and 6m depth respectively)			

5.3 Topsoil

5.3.1 Topsoil was encountered in all exploratory holes ranging in thickness from 0.1m to 0.4m and on average around 0.3m thick. The topsoil was generally described as brown to dark brown sandy slightly gravelly clay.

5.4 Made Ground

5.4.1 Made ground was not encountered in any of the exploratory holes across the site. Where the alignment ties in with the existing A40 (Redstone Junction, B4313 and the Penblewin Roundabout) it is anticipated that Made Ground will be associated with the existing road. In addition, Made Ground may be encountered in discrete locations across the site associated with the sources identified in Section 3.10.10.

5.5 Glacial Deposits

General

5.5.1 Glacial Deposits are interpreted within the exploratory holes towards the centre of scheme from chainage Ch0+750 to 1+400 on a side slope falling from the west to the east.

5.5.2 The scheme crosses the strata on embankment that is around 4.5m for the vast proportion of the extent but is locally 10m high above the existing stream at around chainage Ch1+380.

5.5.3 The Glacial Deposits were encountered below the topsoil and where penetrated varied in thickness from 0.5m to 8.5m. The Glacial Deposits are generally thicker from Ch0+880 to 1+050 (around 5m thick) and reduce in thickness either side of this chainage extent apart from RCEBH08 where up to 8.5m is interpreted.

Description

5.5.4 The Glacial Deposits were generally described as firm to very stiff orange grey brown sandy gravelly clay with cobble and boulder content. The gravels and cobbles are of mudstone and sandstone. The Glacial Deposits were recovered as soft clay in RCEDS06a, RCEDS06b, RCEDS10 and RCETP10 up to 1m thick. Borehole collapse was recorded in RCEBH08 from 6.5 to 7.5m depth. Air mist flush was used

from 4.5m depth that may have flushed out a more granular layer in the Glacial Till but based on the borehole log there is no evidence to confirm this.

5.5.5 The material descriptions of the Glacial Deposits in the logs are very similar to the weathered rock descriptions. The differentiation of Glacial Deposits has been interpreted based on the sandstone within the gravel component that has not been logged within the underlying Dicranograptus Formation.

Classification

5.5.6 Bulk unit weight was determined as part of the undrained triaxial and oedometer testing. Laboratory determined bulk unit weight ranged from 1.8 to 2.37Mg/m^3 with an average value of 2.2Mg/m^3. Based on the guidance presented in BS8004:2015, this is likely to be on the high end of a high strength clay. The laboratory testing recorded a single test result 1.8Mg/m^3 with a further 6 tests recording values of 2.2 to 2.37Mg/m^3. The average value of 2.2Mg/m^3 is deemed reasonable on this basis. As such it is recommended that a bulk unit weight of 2.2Mg/m^3 (or 22kN/m^3) is adopted as a characteristic value.

5.5.7 Thirty-one natural moisture content tests and twenty-nine Atterberg Limit tests were conducted on the Glacial Deposits. The natural moisture content and Atterberg Limit tests are presented below.

Table 4 Summary of classification testing – Glacial Deposits [22]

Property	Range	Derived value
Natural moisture content (%)	4.9 to 48 (generally 11 to 27)	17 (average)
Liquid Limit (%)	26 to 76 (generally 26 to 53)	36 (average ignoring high value of 76%)
Plastic Limit (%)	11 to 44 (generally 11 to 23)	16 (average ignoring high value of 44%))
Plasticity Index (%)	13 to 32	20 (average)

5.5.8 The natural moisture content with depth is presented on Figure 12. The results are relatively consistent with depth with slightly higher values recorded in the top 0.5m. The high value of 48% is associated with a soft clay encountered in RCEDS06a at 0.4m depth.

5.5.9 The Atterberg Limits are plotted on a Casagrande Chart, see Figure 13 that shows the material is a clay of low to intermediate plasticity. A single test result falls within the high plasticity clay category associated with RCEDS07. Figure 13 suggests two groupings of data (a low plasticity and an intermediate plasticity grouping) but on examination of the data sets there is no obvious spatial grouping associated with the data. An outlier with the highest liquid limit and plastic limit values plots below the A line on Figure 13 and would be classified as a silt. However, the sample is the soft clay (RCEDS06a) with the high moisture content of 48%. For the single high plasticity clay test there is no obvious indication from the borehole log to suggest why the material is high plasticity.

5.5.10 There is some variation of the Atterberg Limits with depth (refer to Figure 14) where liquid limit is increased above 2.5m depth. This may indicate intermediate plasticity clay within the top 2.5m. The moisture content is either slightly below or slightly above the plastic limit.

5.5.11 Twenty seven Particle Size Distribution tests were undertaken in Glacial Deposits (refer to Figure 15). The curves generally correspond to the logs descriptions and classify the Glacial Deposits as generally a cohesive material with varying proportions of fine to coarse sand and gravels. Three of the gradings indicate that the material is a clayey to slightly clayey gravel whereas the logs at these sample depths record the material as cohesive.

5.5.12 Ten organic matter contents and eleven loss on ignition tests were carried out on Glacial Deposits from 0.5 to 3.5m depth. Organic matter content varied from 1.1 to 1.9% and loss on ignition varied from 2.8 to 7.9%. Based on the guidance on BS EN 14688-2 the material would not be considered organic.

Strength parameters

Undrained strength

5.5.13 Twenty-five standard penetration tests were undertaken in the Glacial Deposits, see Figure 16. The values ranged from 8 to 462 and increased with depth. The data indicates a lower set of SPT N values with depth and a higher set of SPT N values depth. On review of the logs, the lower set of SPT N is associated with material that has no cobble content logged whilst the higher set of SPT N values has low cobble and boulder content logged. It is anticipated that the presence of cobbles is

influencing the N values. The following characteristic SPT N profile is recommended:

Less than 3m depth N = 15

Greater than 3m depth N = 15+6.5z (where z is the depth below 3m)

5.5.14 The following correlation from SPT N values to undrained shear strength is proposed [23]:

$$c_u = f1 \times N$$

5.5.15 Based on a lower bound N value of 15, and an f1 coefficient of 5.5 (based on an average plasticity index of 20%) a c_u of 80kPa is proposed. This corresponds to a high strength (or stiff) description as generally logged in the exploratory holes.

5.5.16 Four quick undrained multistage triaxial compression tests were carried out at depths less than 3m, see Figure 17. The following undrained shear strengths were reported 58, 72, 101 and 208kPa. The laboratory undrained strengths generally agree with the proposed correlation adopted to obtain undrained shear strength from SPT N.

5.5.17 Based on the above and the logs descriptions the following characteristic shear strength profile is proposed:

Less than 3m depth c_u = 80kPa

Greater than 3m depth c_u = 80+35z (kPa) (where z is the depth below 3m)

Drained strength

5.5.18 Correlations from BS8004:2015 are proposed [24] to derive drained shear strength parameters.

5.5.19 The following correlation between plasticity index and characteristic angle of friction value is proposed (adopting a plasticity index of 20%).

$$\varphi'_{cv,k} = \left(42° - 12.5\, log_{10}\, I_p\right) = 26°$$

$$c'_{cv,k} = 0kPa$$

Consolidation

5.5.20 Six one-dimensional consolidation tests were undertaken, see Figure 18. The void ratio versus log pressure plots indicate that the material is over consolidated. Recorded values of the coefficient of volume compressibility (m_v) vary over the pressure range applied (6kN/m^2 and 400kN/m^2) from 0.91m^2/MN to 0.05m^2/MN but in general typical range from 0.3m^2/MN to 0.05m^2/MN. The typical range generally corresponds to m_v values associated with firm over consolidated clays [22].

Stiffness

5.5.21 The characteristic undrained and drained Young's Moduli (E_{uk} and E'_k) has been derived for the cohesive material using the following correlation by Stroud presented in CIRIA 143 [25].

$E_{uk} = 1.1 \times N_{60}$ (MPa)

$E'_k = 0.9 \times N_{60}$ (MPa)

5.5.22 Based on the characteristic SPT N profile presented in 5.5.14 and 5.5.15, the following stiffness parameters are proposed:

Table 5 Summary of proposed stiffness moduli – Glacial Deposits

Depth	Undrained Youngs Modulus (E_{uk}) MPa	Drained Youngs Modulus (E'_k) MPa
Less than 3m	16.5	13.5
Greater than 3m	16.5+7z (where z is the depth below 3m)	13.5+6z (where z is the depth below 3m)

Permeability

5.5.23 Soakaway test SA12 was conducted in the Glacial Deposits at 1.6m depth. An infiltration rate could not be determined due to insufficient outflow. No groundwater was encountered in the pit. Borehole RCEBH09 (located 40m to the north west) struck groundwater at 1.6m. The lack of infiltration may reflect a shallow groundwater level.

5.6 Haverford Beds

General

5.6.1 The Haverford Beds were encountered towards the west of the scheme from chainage 0+000 to 0+360 (based on the geological boundaries indicated on Drawing A40PRC-ARP-EGT-SWI-DR-LE-0002. The Haverford Beds over this extent comprise the Gasworks Mudstones and the Cethings Sandstone.

5.6.2 The exploratory holes have generally encountered a weathered bedrock, that in one location overlies intact bedrock.

5.6.3 The weathered Haverford Beds were encountered underlying the topsoil and varied in thickness from 0.7m to 2.9m.

5.6.4 The scheme crosses the strata in cut that is a maximum of 3m deep.

Description

5.6.5 The weathered material was typically described as a pale brown slightly clayey to clayey sandy gravel of sub angular to angular fine to coarse sandstone with low to medium cobbles of sandstone. Within RCETP01 (western extent of the scheme), the gravel was recorded as a mudstone and is considered to represent the Gasworks Mudstone of the Haverford Beds. Within RCETP03, a firm slightly sandy gravelly clay, 1.6m thick, was recorded above the gravel.

5.6.6 The material was noted to be difficult to dig below 1.8m and 2.8m in RCETP01 and RCETP02 respectively.

5.6.7 Intact Haverford Beds were encountered in one exploratory hole (RCEBH01) as strong light grey to light brown fractured slightly weathered sandstone. The material was encountered at 1m depth. The following rock mass details were noted:

a) Zones of core loss were noted from 1.5m to 10m depth ranging in thickness from 0.1m to 2.5m.

b) RQDs of 0 were predominantly recorded with a maximum RQD of 27.

c) Fractures were described as sub horizontal, open, clean and rough to planar with an average fracture spacing ranging from 30mm to 70mm.

Classification

5.6.8 No bulk unit weight testing on the weathered or intact material was conducted. Based on the recommendations in BS8004:2015 a value of 20kN/m^3 is proposed for the weathered material and a value of 22kN/m^3 for the intact.

5.6.9 A total of seven natural moisture content and Atterberg Limit tests were conducted in the weathered material and one natural moisture content test in the intact material.

5.6.10 Natural moisture contents range from 12 to 19% with one higher moisture content of 27% in RCEBH01 in the weathered material. The higher moisture content is associated with material logged as a clayey gravel and represents the clay fraction of the material.

5.6.11 A natural moisture content of 1.7% was recorded in the intact material.

5.6.12 Atterberg limit testing on the weathered material recorded plastic limits from 10 to 16%, liquid limits from 22 to 50% and plasticity index from 12 to 35% with an average of 17% (refer to Figure 20). The Atterberg Limits with depth are relative constant (refer to Figure 19) and the moisture contents are slightly above the plastic limits.

5.6.13 Figure 21 indicates that the material passing the 425mm sieve is a clay of low plasticity except for one test recording the material as intermediate plasticity. The percentage of material passing the 425mm sieve ranges from 35% to 80%. The intermediate plasticity sample (RCEBH01) recorded 80% of material passing the 425mm sieve but has been described as a clayey gravel in the log.

5.6.14 Seven particle size distributions were undertaken in the weathered material and one particle size distribution test within the intact material (zone recovered as a gravel in RCEBH01) (refer to Figure 21). Two of the tests indicate that the material has a fines content in excess of 60% and the remaining five (and the one on the intact material) indicate that the samples were predominately granular and had fines of between 8 to 30% and are predominantly gravels.

Compaction and CBR

5.6.15 One dry density versus moisture content relationship test was

undertaken using a 2.5kg hammer, see Figure 22. The material tested was a silty sandy clay obtained from 0.5 depth in RCETP03. The Optimum Moisture Content (OMC) was 15%.

5.6.16 Two in-situ CBR tests were taken within trial pits RCETP01 and RCETP02 at 0.3m depth. Descriptions recorded as part of the tests reported the tested material to be a clayey slightly sandy gravel and a slightly sandy slightly gravelly clay.

5.6.17 In-situ CBR values were 4.6% and 6.8% with moisture contents of 20 and 16% respectively.

Strength

5.6.18 The Weathered Haverford Beds were only encountered in trial pits and no Standard Penetration Tests or laboratory strength tests were undertaken in this formation.

5.6.19 Based on the material descriptions of predominantly firm an undrained strength of around 50kPa is anticipated for the cohesive Weathered Haverford Beds.

5.6.20 The constant volume angle of shearing resistance (φ'_{cv}) can be determined for cohesive material using the relationship with plasticity index provided in BS8002:2015 [26]. Based on the average plasticity index of 17% the correlation suggests a φ'_{cv} of 27º.

5.6.21 If the weathered material is treated as a granular material the following relationship from BS8004:2015 [24] is proposed to calculate the characteristic angle of friction.

$$\varphi'_{ck,k} = 30 + \varphi'_{ang} + \varphi'_{PSD} = 30 + 3 + 4 = 37°$$

5.6.22 Where the following parameters have been adopted:

φ'_{ang} = 3° based on the typical log description of the gravel as sub-angular to angular.

φ'_{PSD} = 4° based on the uniformity coefficient greater than 6.

5.6.23 The results of the extrapolated SPTs conducted in the intact material in RCEBH01 are presented on Figure 23. In general there is an increase in

SPT N with depth from N = 150 at around 1m below ground level increasing to above N=500 at around 4m below ground level.

5.6.24 Point load index testing with depth for the Haverford Beds is presented on Figure 24. Two tests were conducted that recorded point load indices (Is_{50}) of 0.7 and 3.3 MPa.

5.6.25 It is anticipated, (based on the cutting depth) that the cut will predominantly be located within the weathered material or if the intact material is encountered it is likely to behave as a gravel (for example the upper 3m of the material in RCEBH01 is fractured and was recovered as a gravel). As such if the intact rock is exposed it is likely that the material could be treated as a "soil" and frictional strength parameters could apply as presented in 5.6.20.

5.6.26 If the rock encountered in the cut is intact then persistent discontinuities may control the stability of the rock cut. The discontinuities in the boreholes have generally been described as sub horizontal, open, clean and rough to planar with average fracture spacing ranging from 30mm to 70mm.

5.6.27 There is a variety of bedding dip orientations shown in the area surrounding the cut (refer to Drawing 2). The fractures logged are sub horizontal and there is a risk that if the bedding dip is unfavourable there could be potential for kinematic failures (i.e. sliding, toppling and wedge failures). The kinematic stability will (in addition to discontinuity geometry) be dependant on the strength parameters for the discontinuities.

5.6.28 A review of published information relating to the strength parameters of discontinuities has been undertaken. This indicates that an angle of friction in the region of 35° is typical for sandstones with clean joints [27]. The kinematic stability of the cuttings will be considered as part of the earthworks design and presented in the preliminary GDR.

Stiffness

5.6.29 As a cutting is currently proposed over the extent of the Weathered Haverford Beds Formation, a stiffness value was not derived for the material.

Permeability

5.6.30 Soakaway testing conducted in RCETP01 at 2m depth recorded infiltration rates of $1.35x10^{-5}$ to $1.88x10^{-5}$ m/s.

5.6.31 Based on log descriptions, the weathered material tested was predominantly granular in nature and therefore infiltration to the ground would be expected. No groundwater was encountered in the trail pit or other trail pits within the weathered Haverford Beds. Monitored ground was recorded at around 4m depth. The highest infiltration rate ($3.07x10^{-5}$m/s) was recorded on the first test undertaken with the infiltration rate decreasing with each subsequent test to the lowest infiltration rate ($1.57x10^{-5}$m/s) recorded on the last test undertaken. The infiltration rate calculated for the consecutive tests decreases by roughly 50% and could be the result of the ground in the vicinity of the test becoming locally saturated.

5.7 Slade and Redhill Formation

General

5.7.1 The Slade and Redhill Formation underlies the scheme on either side of the interpreted fold structure, in the west from chainage Ch0+380 to 0+750, the Redstone Road Overbridge (SBR-0572), Redstone Road Junction and B4313 Tie in; and in the east from chainage Ch1+400 to 1+799.313 (end of the scheme) and the proposed Penblewin Roundabout and side road.

5.7.2 The scheme crosses the strata:

a) Predominantly in cut along the mainline with limited lengths on embankment;

b) On embankment for the B4313 Tie in and approaches to the Redstone Road overbridge;

c) At grade for the Penblewin Roundabout.

5.7.3 The exploratory holes within the strata encountered a weathered and intact material. The interpretation of the test results on the weathered and intact material is presented separately below due to the larger quantum of testing within the strata.

5.8 Weathered Slade and Redhill Formation

Description

5.8.1 The Weathered Slade and Redhill Formation were generally recovered as:

a) Soft to firm pale brown grey to orange brown slightly silty slightly sandy gravelly clay with gravel of fine to coarse mudstone (generally encountered below the topsoil within trial pits and dynamic samplers (total of 4 exploratory holes)); 0.25m to 2.1m thick.

b) A clayey sandy gravel with gravel of sub-angular to angular of mudstone. Based on visual inspections the material was described as dense to very dense but with some locations described as loose. The thickness of the material varied from 0.3 to 3.7m.

Classification

5.8.2 Laboratory determined bulk density on the cohesive material (drained shear box tests) recorded values of 16 to 21kN/m^3. A characteristic value of 20kN/m^3 is proposed. Bulk density for the granular material has not been determined but based on the guidance in BS8004:2015 a value of 20kN/m^3 is also proposed.

5.8.3 Thirty natural moisture content tests were conducted within the material and the natural moisture with depth is presented on Figure 25. Natural moisture content varies from 10% to 25% up to 2m depth. Higher values above 30% were recorded and relate to samples that are clayey gravels or firm gravelly clay. The highest values (64% and 59%) are from RCEDS01 (0.5m and 1.2m depth) that are described as either a clayey sandy gravel or sandy gravelly clay with 21% and 86% of the material passing the 0.425mm sieve respectively. There is no evidence in the log to suggest why these high moisture contents were recorded.

5.8.4 Twenty-two Atterberg Limits were undertaken in the material. The results have been plotted on Casagrande Plot (refer to Figure 26). The testing indicates the material passing the 0.425mm sieve is a clay of low to intermediate plasticity. High to extremely high plasticity clay and silt results are recorded that relate to the high moisture content samples (above 30%) from RCETP05, RCEDS01, RCEDS03 and RCEDS05. The material logged at the test depths from these holes was either a clayey sandy gravel or sandy gravelly clay with the percentage material passing the 0.425mm sieve either above 70% or below 30%. There is

no other evidence to indicate why the tests from these holes are behaving as extremely high plasticity clay or silt.

5.8.5 The natural moisture content and corresponding Atterberg Limit tests have been plotted with depth (refer to Figure 27). The natural moisture content generally lies above the plastic limit.

5.8.6 Thirty three particle size distribution tests were undertaken in the material, see Figure 28. Particle size distribution testing reflects the logged description of the material. Twenty five tests out of 33 indicate that the samples were predominately granular and had less than 35% fines. The tests show that the material is generally well graded. The remaining tests indicate the samples are cohesive with fines of between 60 and 90%.

Compaction and CBR

5.8.7 Six dry density versus moisture content relationship tests were undertaken using a 2.5kg hammer, see Figure 29. On inspection of the logs, the material tested was the granular Weathered Slade and Redhill Formation generally obtained from 0.5 to 1m depth. The Optimum Moisture Contents (OMC) ranged from 12% to 16%.

5.8.8 The material retained on the 20mm size sieve (medium gravel sized and above) varied from all test material passing (2 tests) to between 20% and 80% of the material passing. This suggests a degree of variability in the material that is reflected by the particle size distribution tests.

5.8.9 Five in-situ CBR tests were taken within trial pits located in the Weathered Slade and Redhill Formation. Descriptions recorded as part of the tests typically recorded the test material to be a clayey slightly sandy gravel except for RCETP05 and RCETP19 that described the material as a slightly silty sandy slightly gravelly to gravelly clay.

5.8.10 In-situ CBR values ranged from 3.5% to 6% with moisture contents ranging from 15 to 18%. The tests conducted in the cohesive material recorded CBRs of 3.5 and 5.6%.

Strength

Undrained strength

5.8.11 No SPT tests or laboratory tests to determine undrained shear strength

of the cohesive Weathered Slade and Redhill Formation were conducted.

5.8.12 Based on the material descriptions of predominantly firm an undrained strength of around 50kPa is anticipated for the cohesive Weathered Slade and Redhill Formation.

Drained strength

5.8.13 Seven Standard Penetration Tests were undertaken in the gravels of the Weathered Slade and Redhill Formation ranging from 4 to 500 (refer to Figure 30). The low value of N=4 was recorded in a gravel, 0.3m thick in RCEDS01 logged as loose and is not considered representative of the material. The remaining SPT N values are above N=37 which corresponds to a dense material.

5.8.14 The following relationship from BS8004:2015 [24] is proposed to calculate the characteristic angle of friction of the granular material.

$$\varphi'_{ck,k} = 30 + \varphi'_{ang} + \varphi'_{PSD} = 30 + 3 + 4 = 37°$$

5.8.15 Where the following parameters have been adopted:

φ'_{ang} = 3° based on the typical log description of the gravel as sub-angular to angular.

φ'_{PSD} = 4° based on the uniformity coefficient above 6.

c' = 0 kPa is proposed.

5.8.16 Two remoulded direct shear box tests were conducted from bulk samples of the cohesive Weathered Slade and Redhill Formation retrieved from RCETP07 at 0.3 and 1m depth. The results are presented on Figure 31. There is a scatter in the test results from which effective stress parameters could range from c' = 0kPa and ϕ' of 28° to c' = 0kPa and ϕ' of 31°.

5.8.17 To allow for a comparison of the laboratory based strength testing, constant volume angle of shearing resistance (φ'_{cv}) can be determined for cohesive material using the relationship with plasticity index provided in BS8002:2015 [26]. The shear box sample at 1m depth recorded a plasticity index of 12% that corresponds to a φ'_{cv} of 29°.

5.8.18 It is recommended that the following characteristic drained strength parameters are adopted for the cohesive material based on the shear box testing: c' = 0kPa and ϕ' of 31°. It is anticipated that the gravel component of the material will contribute to the drained strength that is not fully accounted for in the above as the shear box testing removes material that is greater than 2mm and the Atterberg Limit testing is conducted on material passing the 0.425mm sieve.

Stiffness

5.8.19 The characteristic drained Young's Modulus (E'_k) has been derived using the correlation for granular materials by Stroud presented in CIRIA 143 [25].

$E' = 1 \times N_{60}$ (MPa)

5.8.20 Ignoring the unrepresentative SPT N value of 4 and adopting a typical value of SPT N = 37, an E' value of 37MPa is proposed and a rounded E'_k value of 40MPa is recommended.

5.9 Intact Slade and Redhill Formation

Description

5.9.1 The intact Slade and Redhill Formation is typically encountered as very weak to weak brown grey to dark grey slightly to moderately weathered mudstone. Within RCEBH13 (west of the site) and boreholes RCEBH10 and RCEBH11 (towards the east of the site encountered) it is described as a brown grey to dark grey slightly weathered weak to medium strong siltstone that is heavily weathered within the top 3m becoming moderately weathered. Within RCEBH11, moderately strong siltstone was found to underlie weak mudstone from 4.6m depth.

5.9.2 The following summarises the rock quality information logged:

a) RQD varies but in general is 0 to 15 (refer to Figure 32) but RQDs between 20 and 40 are recorded below 5m depth in RCEBH03, RCEBH04, RCEBH10, RCEBH11, RCEBH13 and RCEBH14.

b) A number of the boreholes recorded very poor recovery or non intact zones where the material was recovered as a gravel, namely: RCEBH02 (2 to 11m), RCEBH04 (2 to 12m), RCEBH11 (Non intact bands up to 0.4m thick from 1m to 16m depth), RCEBH12 (4.8 to 11.7m), RCEBH14 (2.5 to 6.8m depth) and RCEBH15 (predominantly non intact with small bands of intact rock).

c) Discontinuities were logged as sub horizontal to 45^{o} fractures with brown staining. The fracture index varies from 7 to 39 fractures per metre of core. The fractures were recorded as planar, smooth and rough.

5.9.3 Within the trial pits the rock was recovered as a pale brown to grey brown dense sandy to slightly clayey/clayey gravel of angular to sub angular fine to coarse mudstone. The material was hard to dig from 1.2m to 2.5m (RCETP05 and RCETP06) and very difficult to dig from 2.7m depth (RCETP05)

Classification

5.9.4 No laboratory determined bulk density was conducted. A value of 22kN/m^3 is recommended based on the recommendations of the A40 LVP scheme [4].

5.9.5 Thirty natural moisture content tests were conducted on the intact Slade and Redhill Formation and are presented on Figure 33. The natural moisture content generally varies from 2 to 10% from 1m to 10m depth with four values between 10 and 17% at depths of less than 1m below ground level. These higher moisture content results are associated with samples recovered as gravel.

5.9.6 Three Atterberg Limits were undertaken in the material. The results have been plotted on Casagrande Plot (refer to Figure 26 plot shared with weathered material). The testing indicates the material passing the 0.425mm sieve is a clay of low to intermediate plasticity.

5.9.7 Thirty particle size distribution tests were conducted on the intact rock from boreholes (core samples) and trial pits (refer to Figure 34). The testing indicates fine percentages of less than 20% with the material primarily being a slightly clayey slightly sandy coarse gravel.

Compaction and CBR

5.9.8 Three dry density versus moisture content relationship tests were undertaken using a 2.5kg hammer, see Figure 35. On inspection of the logs, the material tested was mudsone recovered as a slightly silty gravel from 1.5m depth. Optimum Moisture Contents (OMC) of 11% to 13% were recorded .

Strength

5.9.9 Fifty three Standard Penetration Tests were undertaken in the Slade and Redhill Formation ranging from 50 to in excess of 600 and are presented on Figure 30. In general, SPT N values increase with depth. The following SPT N profile is assumed that ignores three low N values from RCEBH02 and RCEBH15 that are associated with poorly recovered and highly fractured zones):

$N = 50 + 35z$ (where z is the depth below 1.5m)

5.9.10 Point load index testing with depth for the Slade and Redhill Formation is presented on Figure 36. Twenty five tests were conducted that recorded point load indices (Is_{50}) of 0 and 2.8 MPa. In general the data set ranges from 0.1 to 0.4MPa with four outliers recording point load indices of 0.7, 1, 1.2 and 2.8MPa.

5.9.11 Due to the fracturing of the bedrock and sample recovery, no Unconfined Compressive Strength (UCS) tests was undertaken on the Mudstone. UCS of the bedrock can be correlated from the Point Load tests. There are numerous publications providing guidance on the multiplication factor for mudstones which generally are between 15 and 24. It is proposed to use a multiplication factor of 21 (as was adopted on the LVP scheme [4] and the results are shown on Figure 37. The derived values of UCS are commonly in the range of 2MPa to 8MPa which equates to a very weak to weak rock which broadly corresponds with the log descriptions. A characteristic value for the UCS of 5MPa is recommended for the Mudstone.

5.9.12 Rock mass parameters have been derived using RocLab which is based on the Hoek-Brown criterion. The rock mass parameters for the Mudstone of the Slade and Redhill Formation are as follows:

$\varphi' = 20°$

$c' = 150$ kPa

5.9.13 Details of the RocLab assessment (refer to Appendix B) are summarised below:

a) The Geological Strength Index (GSI) value adopted are based on the review of the logs descriptions for the boreholes in the cuttings

to determine the characteristic rock structure and surface condition.

b) The rock structure is assumed to be blocky/disturbed and the surface condition of the discontinuities as fair (smooth, moderately weathered and altered surfaces) giving an assumed GSI of 50

5.9.14 A remoulded, consolidated direct shear box test was conducted on a bulk sample retrieved from 3m depth in RCETP05 within the intact Slade and Redhill Formation. The interpreted strength from the test is as follows:

$\varphi' = 31°$

$c' = 0$ kPa

5.9.15 The material tested is described as a clay and the test was conducted on material finer than 2mm (i.e. the coarse sand and gravel component has been removed). The interpreted ϕ' agrees with the RocLab assessment and the difference with the drained cohesion is related to the material preparation in the shear box.

5.9.16 Based on the cross sections through the cuttings (refer to Figure 6 and Figure 9) that are within the Slade and Redhill Formation, the rock encountered in the boreholes is generally fractured and was of poor recovery (recovered as a gravel or contained numerous non intact zones) the parameters determined from RocLab may not be representative.

5.9.17 If the rock encountered in the cut is intact then persistent discontinuities may control the stability of the rock cut. The discontinuities in the boreholes have generally been described as sub horizontal to 45^{o} fractures with brown staining, planar, smooth and rough with the fracture index varies from 7 to 39 fractures per metre of core. Based on the BGS mapping (refer to Drawing 2) the following is interpreted:

a) the cut orientation of Cutting 2 runs parallel to the anticipated dip direction of the beds

b) the orientation of Cutting 3 runs at a skew to the dip direction. However, the bedding is anticipated to dip into the higher northern face of the cut.

5.9.18 The kinematic stability will (in addition to discontinuity geometry) be dependent on the strength parameters for the discontinuities. A review

of published information relating to the strength parameters of discontinuities was undertaken as part of the LVP scheme. This indicates that an angle of friction in the region of 30° is typical for mudstones and there may be some cohesion [4].

5.9.19 Dip direction, cut geometry and fracture geometry will need to be assessed as part of the cutting stability design.

Stiffness

5.9.20 Rock mass stiffness (E_m) has been estimated based on intact rock strength and discontinuity spacing (BS8004:1986) [28]

5.9.21 For the Slade and Redhill Formation, a derived intact compressible strength of 5MN/m^2 has been used. An Mr value of 75 has been selected (corresponding to uncemented mudstones (Table 4 and Appendix A of BS8006:1986)). Based on the RQD and fracture spacing the rock would be classified as poor quality therefore the value of j is 0.2. This yields a rock mass stiffness of 75MN/m^2.

5.9.22 The near surface stiffness is similar to that determined for the granular Weathered Slade and Redhill Formation and as such for embankment settlement design founding on the strata the following is recommended.

Table 6 Summary of proposed stiffness profile – Slade and Redhill Formation

Depth	**Youngs Modulus (E'k) (MPa)**
Less than 1.5m	40
1.5m to 3.5m	40 increasing to 75
Greater than 3.5m	75

5.10 Dicranograptus Beds Formation

General

5.10.1 The Dicranograptus Beds Formation (weathered and intact) are encountered on each limb of the interpreted anticline fold from chainage 0+740 to 0+900 and 1+060 to 1+400. The strata underlies the Glacial Till on the west of the fold (0+740 to 0+900) but are both partially overlain by the Glacial Till or topsoil on the east of the fold.

5.10.2 The proposed scheme crosses the strata on embankment over the chainage extents described above.

5.10.3 **Description**

Weathered Dicranograptus Beds Formation

5.10.4 Generally described as a clayey sandy gravel. The gravels were described as sub-angular to angular of mudstone. Based on visual inspection the material is described as loose to very dense. Within RCETP12 the material was encountered as a sandy gravelly clay with low cobble content of mudstone. Borehole collapse was recorded in RCEDS09.

5.10.5 The strata underlies the Glacial Till (with the exception of RCEBH08 and RCEBH09) at depths of 0.45 to 5.3m below ground level and is 0.1 to 4.7m thick.

Intact Dicranograptus Beds Formation

5.10.6 Encountered in four exploratory holes as very weak to moderately weak dark grey black slightly weathered siltstone/mudstone.

5.10.7 Two fracture sets noted: 1. sub horizontal planar, open smooth; and 2. subvertical to vertical, open, clean, stepped, smooth with occasional staining on the fractures; noted as heavily fractured in RCSBH08.

5.10.8 RQDs generally recorded as 0 to 7 (RQDs of 32 noted towards the base of two of the boreholes), refer to Figure 38. Non intact core lengths of up to 0.75m noted in several of the boreholes.

Classification

5.10.9 No bulk unit weight testing on the weathered or intact material was conducted. Based on the recommendations in BS8002:2015 [26] a value of 20kN/m^3 is proposed for the weathered material and a value of 22kN/m^3 for the intact.

5.10.10 Twelve natural moisture content tests and ten Atterberg Limit tests were conducted on the weathered Dicranograptus Beds Formation and three natural moisture content tests on the intact material. The natural moisture content and Atterberg Limit tests are presented on Figure 39, Figure 40 and Figure 41. The following summarises the testing.

Table 7 Summary of classification testing – Dicranograptus Beds Formation

Property	Range	Derived value
Natural moisture content (%)	Weathered 12 to 27 (12 tests) Intact 5.3 to 7.9 (3 tests)	Weathered 17 (average)
Liquid Limit (%)	Weathered 28 to 42 (10 tests)	35 (average)
Plastic Limit (%)	Weathered 14 to 24 (10 tests)	18 (average)
Plasticity Index (%)	Weathered 12 to 22 (10 tests)	17

5.10.11 The weathered Dicranograptus Beds Formation show general spread in natural moisture content over the top 4m and the intact material has a relatively constant natural moisture content with depth.

5.10.12 The Atterberg Limit testing was conducted on material logged as clayey gravel of which typically 80% of the material passed the 0.425mm sieve. The Atterberg testing indicates the material passing the 0.425mm sieve is a clay of low to intermediate plasticity. The natural moisture content of the material varies from being lower than the plastic limit to slightly above the plastic limit.

5.10.13 Eleven particle size distribution tests were undertaken in the weathered material, see Figure 42. The testing broadly indicates three groupings: 1. Fines in excess of 70%, 2. Fines of between 35 and 50% with a well graded proportion of sand and gravel; 3. Fines less than 25% with a higher proportion of gravel material.

5.10.14 Three particle size distribution tests were undertaken in the intact material, see Figure 42. The testing indicates fine percentages of less than 10% with the material primarily being a slightly clayey slightly sandy coarse gravel.

Strength

5.10.15 Five Standard Penetration Tests were undertaken in weathered material and eleven undertaken in the intact material and are presented against depth on Figure 43. The SPT N values ranged from 15 to 65 in the weathered material and a characteristic SPT N of 40 is recommended for the weathered material based on the average value of the 5 test results (refer to Figure 43). The SPT N values ranged from 128 to 2000 in the intact material.

5.10.16 The weathered material has been logged as a granular deposit, but the laboratory testing suggest it could behave as a cohesive material. No in situ or laboratory strength testing was conducted on the weathered material and correlations (based on cohesive and granular materials) to obtain undrained and effective strength parameters are to be adopted.

Undrained shear strength

5.10.17 The following correlation from SPT N values to undrained shear strength (c_u) is proposed for the weathered material [23]:

$$c_u = f1 \times N$$

5.10.18 Where the coefficient f_1 is based on plasticity index. Using a plasticity index of 17%, an f1 of 5.5 is proposed.

5.10.19 Based on an N value of 40, a c_u of 200kPa is proposed for the weathered material.

Drained strength

5.10.20 No laboratory testing to derive drained shear parameters were conducted on the weathered material. Correlations from BS8004:2015 are proposed [24] to derive drained shear strength parameters for the weathered material.

5.10.21 The following correlation between plasticity index and characteristic angle of friction value is proposed. Plasticity index values range from

12% to 22%. A value of 17% is selected based on the average value.

$$\varphi'_{cv,k} = \left(42° - 12.5\, log_{10}\, I_p\right) = 27°$$

$$c'_{cv,k} = 0kPa$$

5.10.22 The drained strength predicted above is considered overly conservative as it is anticipated that the gravel component of the material will contribute to the drained strength that is not fully accounted for in the Atterberg Limit test that is conducted on material passing the 0.425mm sieve. The material has been excavated and described as a gravel and as such the following relationship from BS8004:2015 [24] is proposed to calculate the characteristic angle of friction assuming the material behaves as a granular material.

$$\varphi'_{ck,k} = 30 + \varphi'_{ang} + \varphi'_{PSD} = 30 + 3 + 4 = 37°$$

5.10.23 Where the following parameters have been adopted:

φ'_{ang} = 3° based on the typical log description of the gravel as sub-angular to angular.

φ'_{PSD} = 4° based on the uniformity coefficient above 6.

c' = 0 kPa is proposed.

5.10.24 Six point load tests were conducted within the intact material that ranged from 0.1 to 2MPa. Two high values of 1 and 2 MPa were recorded in RCEBH09 and RCEBH05 respectively where the logged descriptions indicate that occasionally strong bands are present.

5.10.25 Due to the fracturing of the bedrock and sample recovery, no Unconfined Compressive Strength (UCS) tests was undertaken on the intact material. UCS of the bedrock can be correlated from the Point Load tests. There are numerous publications providing guidance on the multiplication factor for mudstones which generally are between 15 and 24. It is proposed to use a multiplication factor of 21 (as was adopted on the LVP scheme [4]) and the results are shown on Figure 44. The derived values of UCS are commonly in the range of 2MPa to 6MPa which equates to a very weak to weak rock which broadly corresponds with the log descriptions. A characteristic value for the UCS of 5MPa is recommended for the Mudstone.

5.10.26 Rock mass parameters have been derived using RocLab which is based on the Hoek-Brown criterion. The rock mass parameters for the intact material is as follows:

$\varphi' = 26°$

$c' = 200$ kPa

5.10.27 Details of the RocLab assessment (refer to Appendix B) are summarised below:

a) The Geological Strength Index (GSI) value adopted are based on the review of the logs descriptions for the boreholes in the intact material to determine the characteristic rock structure and surface condition.

b) The rock structure is assumed to be blocky and the surface condition of the discontinuities as fair (smooth, moderately weathered and altered surfaces) giving an assumed GSI of 65.

Consolidation

5.10.28 A single one-dimensional consolidation test was undertaken on the weathered material. The void ratio versus log pressure plots indicate that the material is over consolidated. Recorded values of the coefficient of volume compressibility (m_v) vary over the pressure range applied (25kN/m^2 to 400kN/m^2) from 0.69m^2/MN to 0.09m^2/MN but in general typical range from 0.3m^2/MN to 0.08m^2/MN. The typical range generally corresponds to m_v values associated with firm over consolidated clays [22].

Stiffness

5.10.29 The characteristic undrained and drained Young's Modulus (E_{uk} and E'_k) has been derived the weathered material using the correlation for granular materials by Stroud presented in CIRIA 143 [25].

$E_{uk} = 1.1 \times N_{60}$ (MPa)

$E'_k = 1 \times N_{60}$ (MPa)

5.10.30 Based on a lower bound SPT value of 40, an E_{uk} of 44MPa and E'_k of 40MPa are proposed.

5.10.31 Rock mass stiffness (E_m) has been estimated using the equation E_m =

jM_rq_{uc} based on intact rock strength and discontinuity spacing (BS8004:1986 [28]).

5.10.32 For the intact material, a derived intact compressible strength (q_{uc}) of 5MN/m^2 has been used. An Mr value of 75 has been selected (corresponding to uncemented mudstones (Table 4 and Appendix A of BS8006:1986)). Based on the RQD and fracture spacing the rock would be classified as poor quality therefore the value of j is 0.2. This yields a rock mass stiffness of 75MN/m^2.

Permeability

5.10.33 A soakaway test was conducted in RCETP12 at 3.5m depth. Infiltration rate could not be determined due to insufficient outflow. Seepages were noted in RCETP12 at 2.7m. On completion of the trial pit and prior to the soakaway test, infill of the trial pit with groundwater was not recorded. The seepages suggest a shallow groundwater level above the level of the soakaway test and the lack of infiltration may reflect a shallow groundwater level.

5.11 Llandeilo Limestone Formation

5.11.1 **General**

5.11.2 The Llandeilo Limestone Formation is located towards the centre of the scheme from chainage 0+900 to 1+060, either side of the interpreted anticline fold axis. Based on the geological map (refer to Drawing 2) the axis of the fold is marked by a fault. The material underlies Glacial Till over this chainage extent.

5.11.3 The proposed scheme is on embankment over the chainage extents described above.

5.11.4 **Description**

5.11.5 Weathered and intact Llandeilo Limestone Formation was interpreted in two exploratory holes (RCEBH06 and RCETP09).

5.11.6 The weathered Llandeilo Limestone Formation were typically described as orange brown clayey sandy to slightly sandy gravel with low cobble content of mudstone and sandstone. The gravels were angular to sub-rounded of mudstone and sandstone. Where recorded,

the material was described as dense.

5.11.7 The top of the weathered material was encountered at 2.3m and 5m below ground level and where penetrated (RCEBH06) is 4.8m thick.

5.11.8 The intact Llandeilo Limestone Formation was encountered in RCEBH06 typically as moderately weak dark grey siltstone with occasional strong sandy beds up to 30mm thick. The material is logged as slightly weathered with little surface staining. Fractures are sub-horizontal, open, clean planar and smooth with an average fracture spacing of around 10 per metre length. RQDs of 0 were recorded (refer to Figure 45).

5.11.9 The top of the intact material was encountered at 9.8m depth in RCEBH06 and was not penetrated.

Classification

5.11.10 No bulk unit weight testing on the weathered or intact material was conducted. Based on the recommendations in BS8002:2015 [26] a value of 20kN/m^3 is proposed for the weathered material and a value of 22kN/m^3 for the intact.

5.11.11 Three natural moisture content tests and two Atterberg Limit tests were undertaken in the weathered material. No classification testing was conducted on the intact material. The following summarises the testing results:

a) Natural moisture contents of 1.6, 18 and 19% were recorded. The low moisture content was recoded at 9m depth in RCSBH06 within a clayey gravel.
b) The Atterberg Limit testing (conducted on the higher moisture content samples) recorded plastic limit of 17%, liquid limit of 29 to 34% and plasticity indices of 12 and 17. The portion of the material passing the 425µm is of low plasticity.
c) The natural moisture content lies slightly above the plastic limit.

5.11.12 Four particle size distribution tests were undertaken in the weathered material, see Figure 46. Three of these indicate that the samples were predominantly clay material (50 to 80% passing the 0.0063mm sieve). The remaining sample is predominantly a coarse gravel (25% of the material passing the medium size gravel sieve) and reflects the sandstone gravel recoded in the RCEBH06 at the sample depth.

Strength

5.11.13 Four Standard Penetration Tests were undertaken in weathered material and two in the intact. SPT N values ranged from 26 to 120 in the weathered material and 600 to 3000 in the intact (refer to Figure 47).

5.11.14 The weathered material has been logged as a granular deposit, but the laboratory testing suggest it could behave as a cohesive material. No in situ or laboratory strength testing was conducted on the weathered material and correlations (based on cohesive and granular materials) to obtain undrained and effective strength parameters are to be adopted.

Undrained shear strength

5.11.15 The following correlation from SPT N values to undrained shear strength (c_u) is proposed for the weathered material [23]:

$$c_u = f1 \times N$$

5.11.16 Where the coefficient f_1 is based on plasticity index. Using a plasticity index of 17% (highest result tests), an f_1 of 5 is proposed.

5.11.17 Based on the lower bound N value of 30, a c_u of 150kPa is proposed for the weathered material.

Drained strength

5.11.18 The following correlation between plasticity index and characteristic angle of friction value is proposed if the material is cohesive (as presented in BS8004:2015 [24]). A plasticity index of 17% was adopted (highest value).

$$\varphi'_{cv,k} = \left(42° - 12.5\, log_{10}\, I_p\right) = 27°$$

$$c'_{cv,k} = 0kPa$$

5.11.19 The drained strength predicted above is considered overly conservative as it is anticipated that the gravel component of the material will contribute to the drained strength that is not fully accounted for in the Atterberg Limit test that is conducted on material passing the 0.425mm sieve. The material has been excavated and described as a gravel and as such the following relationship from BS8004:2015 [24] is proposed to calculate the characteristic angle of friction assuming the material

behaves as a granular material.

$$\varphi'_{ck,k} = 30 + \varphi'_{ang} + \varphi'_{PSD} = 30 + 3 + 4 = 37°$$

5.11.20 Where the following parameters have been adopted:

φ'_{ang} = 3° based on the typical log description of the gravel as sub-angular to angular.

φ'_{PSD} = 4° based on the uniformity coefficient above 6.

c' = 0 kPa is proposed.

5.11.21 A single point load tests was conducted close to the boundary of the intact material that recorded an $Is_{(50)}$ of 3.2MPa. No Unconfined Compressive Strength (UCS) tests was undertaken on the intact material. As presented for the previous strata, UCS of the bedrock can be correlated from the Point Load tests where a multiplication factor of 21 has been adopted. Based on the single point load test, this would equate to a UCS of 67MPa which equates to a strong rock. The material is described as a moderately weak mudstone and would not agree with the correlated UCS. Due to the limited information a characteristic value for the UCS of 5MPa is recommended as per the mudstones encountered within the other strata.

5.11.22 Rock mass parameters have been derived using RocLab which is based on the Hoek-Brown criterion. The rock mass parameters for the intact material is as follows:

φ' = 26°

c' = 200 kPa

5.11.23 Details of the RocLab assessment (refer to Appendix B) are summarised below:

a) The Geological Strength Index (GSI) value adopted are based on the review of the logs descriptions for the boreholes in the intact material to determine the characteristic rock structure and surface condition.

b) The rock structure is assumed to be blocky and the surface condition of the discontinuities as fair (smooth, moderately weathered and altered surfaces) giving an assumed GSI of 65.

Stiffness

5.11.24 The characteristic undrained and drained Young's Moduli (E_{uk} and E'_k) has been derived for the weathered material using the correlation for granular materials by Stroud presented in CIRIA 143 [25].

$E_{uk} = 1.1 \times N_{60}$ (MPa)

$E' = 1 \times N_{60}$ (MPa)

5.11.25 Based on a lower bound SPT value of 30, an E_{uk} of 33MPa and E'_k of 30MPa are proposed.

5.11.26 Rock mass stiffness (E_m) has been estimated using the equation $E_m = jM_rq_{uc}$ based on intact rock strength and discontinuity spacing (BS8004:1986 [28]).

5.11.27 For the intact material, a derived intact compressible strength (q_{uc}) of 5MN/m^2 has been used. An Mr value of 75 has been selected (corresponding to uncemented mudstones (Table 4 and Appendix A of BS8006:1986)). Based on the RQD and fracture spacing, the rock would be classified as poor quality therefore the value of j=0.2, yielding a rock mass stiffness of 75MN/m^2.

Table 8 Summary of characteristic geotechnical design parameters

Geological unit	Geotechnical Parameter								
	Classification			Strength[(1)]				Stiffness	
	Unit weight	Natural moisture	Plasticity PI	Undrained shear strength (c_u)	Drained cohesion (c')	Angle of shearing resistance (ϕ')	UCS	Drained Elastic Modulus E'	Undrained Elastic Modulus E_u
	kN/m^3	%	%	kN/m^2	kN/m^2	º	MN/m^2	MN/m^2	MN/m^2
Glacial Till	22	17	20	<3m 80 >3m 80+35z (where z is depth below 3m)	0	26	-	<3m 13.5 >3m 13.5+6z (where z is depth below 3m)	<3m 16.5 >3m 16.5+7z (where z is depth below 3m)
Weathered Haverford Beds	20	(16)	(17)	- (50)	0 (0)	37 (27)	-	-	-
Haverford Beds	22	2	-	-	0	37	-	-	
Weathered Slade and Redhill Formation	20	(26)	(25)	- (50)	0 (0)	37 (31)	-	40	-
Slade and Redhill Formation	22	7	(20)	-	150	20	5	75	
Weathered Dicranograptus Beds Formation	20	(17)	(17)	- (200)	0 (0)	37 (27)	-	40	44
Dicranograptus Beds Formation	22	-	-	-	200	26	5	75	
Weathered Llandeilo Limestone Formation	20	(18)	(15)	- (150)	0 (0)	37 (27)	-	30	33
Llandeilo Limestone Formation	22	-	-	-	200	26	5	75	

Note: (1) Classification and strength values in brackets () denote parameters for cohesive material

5.12 Summary of groundwater

Groundwater strikes

5.12.1 Groundwater was struck in all the boreholes (except for RCEBH10) and most of the trial pits (except for RCETP01 to 05, RCETP13 and RCETP16 to TP18). Where encountered groundwater strikes ranged from 0.25m to 12.5m depth.

5.12.2 The following summarises groundwater strikes per strata:

a) Glacial Deposits – 0.25m to 5.5m depth;

b) Haverford Beds –1m depth in RCEBH01;

c) Slade and Redhill Formation – 1.6m in the weathered material (one location RCETP07) and 1.05 to 12.5 in the intact material;

d) Dicranograptus Formation – 1.2 to 3m in the weathered material and 2.5 to 11.5m depth in the intact material;

e) Llandeillo Limestone Formation – 2.3 to 6.2m depth in the weathered material.

5.12.3 Based on the groundwater strike information there is likely to be a shallow groundwater level across the site within the weathered bedrock and the Glacial Deposits.

Monitored groundwater

5.12.4 As part of the investigation, the installed piezometers were monitored both during the works in addition to three rounds of water monitoring undertaken post completion of works from 9th September 2019 to 25th November 2019. Table 7 and Figure 11 present a summary of the monitoring.

Table 9 Summary of installations

Hole ID	RZ Depth	RZ Ground Conditions	Range of monitored water levels	
	m		mbgl	mAOD
RCE-BH01	9 to 10	Haverford Beds Formation (fractured sandstone) Cutting 1	3.64 to 4.53	84.43 to 83.44
RCE-BH02	9.5 to 10.5	Slade and Redhill Formation (mudstone/siltstone; recovered as gravel) Embankment 1	3.99 to 6.54	89.61 to 87.06
RCE-BH03	8 to 10	Slade and Redhill Formation (mudstone) Cutting 2	0 to 0.57	100.06 to 99.49
RCE-BH04	6 to 7.5	Slade and Redhill Formation (mudstone locally grading to a Siltstone) Cutting 2	4.12 to 5.68	96.49 to 94.93
RCE-BH12	7 to 8.5	Slade and Redhill Formation (mudstone). Cutting 2	0.90 to 1.55	102.41 to 101.76
RCE-BH13	8 to 9.5	Slade and Redhill Formation (siltstone) Cutting 2	0 to 1.16	101.9 to 100.69
RCE-BH14	7 to 8.5	Slade and Redhill Formation (mudstone) Cutting 2	0.81 to 1.67	102.85 to 101.97
RCE-BH05	3.5 to 4.5	Glacial Deposits (gravelly clay with low cobble content) Embankment 2a	0 to 0.85	89.74 to 88.89
RCE-BH06	4.5 to 5.5	Glacial Deposits (clayey slightly sandy gravel) Embankment 2a	0.41 to 0.86	88.47 to 87.98
RCE-BH07	4 to 5	Glacial Deposits (gravelly clay with low cobble content) Embankment 2a	0.38 to 0.69	86.11 to 85.77
RCE-BH08	9 to 10.5	Dicranograptus Bed Formation (mudstone (heavily fractured)) Embankment 2b	0.34 to 0.52	80.05 to 79.76
RCE-BH09	2.2 to 3.2	Dicranograptus Bed Formation (mudstone/siltstone) Embankment 2b	0 to 0.54	78.1 to 77.52
RCE-BH10	14 to 16	Slade and Redhill Formation (siltstone) Cutting 3	9.10 to dry	90.96 to 76.66
RCE-BH11	5 to 6.5	Slade and Redhill Formation (siltstone) Cutting 3	0.68 to 1.55	92.61 to 91.66
RCE-BH15	6 to 7.5	Slade and Redhill Formation (mudstone (heavily fractured)) B4313 tie in to A40	4.56 to 5.68	89.06 to 87.87
RCE-BH16	7.5 to 9.5	Slade and Redhill Formation (mudstone) B4313 tie in to A40	2.38 to 3.52	89.46 to 88.32

5.12.5 The response zones installed are generally located in the intact rock of all the bedrock strata encountered across the site. Three installations were installed in the Glacial Deposits. The following summarises the interpretation:

a) Within the Glacial Deposits relatively shallow ground water at depths of less than 1m below ground level were encountered;

b) Within the bedrock (except for the Haverford Beds) the maximum recorded ground water levels generally are within 1m of the ground surface with the exception of RCEBH02, BH04, BH10, BH15 and BH16;

c) RCEBH01 installed in the Haverford Beds recorded a groundwater level of around 4m below ground level.

5.12.6 Based on the monitoring information it is likely that there is a shallow groundwater level across the site with the superficial material, weathered and intact bedrock in hydrostatic continuity. The relatively high groundwater levels monitored from the deeper response zones may be controlled by driving heads in the bedrock controlled by the topography and the geological structure.

5.12.7 The relatively shallow groundwater is supported by the evidence of springs within the scheme vicinity (refer to Section 3.10.1).

5.13 Concrete aggressivity

5.13.1 Various samples of soil and water taken during the site works have been tested in accordance with BRE Special Digest 1 [29]. As there is potential for the presence of pyrite in the mudstones encountered this has been taken into account during the assessment.

5.13.2 The appropriate characteristic values for the various sulphate concentrations and pH values have been determined for the strata sampled in accordance with BRE Special Digest 1 and are presented in Table 10 below. The characteristic values determined were then subsequently used to specify the Design Sulphate and ACEC Classes.

Table 10 Results of Concrete Aggressivity Testing and BRE Assessment

Formation	**No. of samples**	**Characteristic value**						**Design Sulphate Class**	**ACEC Class**
		WS	**AS**	**TS**	**TPS [a]**	**OS [b]**	**pH**		
		Water soluble sulphate (mg/l SO_4)	**Acid soluble sulphate (% SO_4)**	**Total sulphur (% S)**	**Total potential sulphate (% SO_4)**	**Oxidisable sulphides (% SO_4)**			
Glacial Till	8	50	0.45	0.17	0.39	0.08	7.16	DS-1	AC-1
Weathered Haverford Beds	0	Not tested						*DS-1*	*AC-1*
Weathered Slade and Redhill Formation	7	40	0.32	0.135	0.405	0.085	6.98	DS-1	AC-1
Weathered Dicranograptus Beds	3	40	0.33	0.14	0.42	0.09	6.87	DS-1	AC-1
Haverford Beds	2	40	0.21	0.09	0.27	0.06	7.54	DS-1	AC-1
Slade and Redhill Formation	19	50	0.36	0.145	0.435	0.075	7.305	DS-1	AC-1
Dicranograptus Beds	0	Not tested						-	-

Notes

Total Potential Sulphate (TPS) = 3 x Total Sulphur (TS)

Oxidisable Sulphides (OS) = Total Potential Sulphate (TPS) – Acid Soluble Sulphate (AS)

Design sulphate and ACEC Class for the Haverford Beds based on testing from the A40 LVP Scheme

5.13.3 As there is a potential for pyrite to be present within the various mudstone formations, it is necessary to calculate the amount of oxidisable sulphides in the suspected pyritic ground. If the amount of oxidisable sulphides is above 0.3% SO_4, it is likely that pyrite is present; however, as all of the calculated oxidisable sulphide (OS) values are well below the 0.3% SO_4 level stated in BRE Special Digest 1 (see Table 10 above), it is highly unlikely that the ground beneath the proposed alignment is pyritic. Furthermore, as pyrite is unlikely to be present, the total potential sulphate values (TPS) can be negated when determining the Design Sulphate Class.

5.13.4 The Dicranograptus Beds Formation in anticipated to be highly pyritic (refer to Section 3.4.22). The intact material was not tested but based on the logged descriptions no evidence of pyrite was noted and supports the above conclusions.

5.14 Geo-environmental considerations

5.14.1 A geo-environmental assessment has been carried out in line with the methodology outlined in Appendix C. The geo-environmental assessment is contained in Appendix D. The assessment covers the following aspects:

a) Human health and controlled waters risk assessment(s);
b) Chemical suitability of material for reuse;
c) Off-site disposal considerations;
d) Water management;
e) Health and safety considerations during construction; and
f) Potential remediation requirements.

5.14.2 The findings of the assessment concluded that there were no risks posed to human health during construction and operation. Additionally, due to the lack of identifiable sources of contamination and the absence of made ground, it is not anticipated that the scheme will adversely impact water quality. It is therefore considered that the risk posed to human health and controlled waters is low, and that the encountered materials are suitable for reuse along the proposed scheme.

5.14.3 The testing conducted and a summary of the results is presented in Appendix D.

6 Geotechnical risk register

6.1.1 The Geotechnical Risk Register is included in Appendix E. The risk register should be reviewed and updated throughout the detailed design and construction phase to allow the identified risks to be most effectively managed and appropriate mitigation to be considered throughout the design and construction process.

7 Engineering assessment

7.1 General

7.1.1 The following section presents an engineering assessment for the scheme based on the findings and recommendations of this GIR. The assessment aims to present considerations for the geotechnical design elements that will be assessed in the Stage 3 Geotechnical Design Report and in detailed design.

7.1.2 The weathered bedrock encountered during the ground investigation was predominantly recovered as a gravel but some of the classification testing suggests that the material could behave as a cohesive material. It is recommended that the Stage 3 GDR considers the impact of the weathered material behaving as a granular or cohesive material and the impact of the material degrading in cut faces and in embankments due to weathering or breakdown during excavation, haulage and compaction.

7.1.3 The Stage 3 Geotechnical Design Report will incorporate the findings of this GIR and present design ground models and adopted parameters for the elements discussed in this section.

7.1.4 Scheme elements discussed within this section include the following:

a) Earthworks – Cuttings;
b) Earthworks – Embankments: most of the scheme is located on embankment that in places are relatively high (up to 10m);
c) Drainage;
d) Pavement;
e) Structures – Redstone Road Overbridge;
f) Structures – culverts / animal crossings.

7.2 Earthworks – Cuttings

Cut slope stability

7.2.1 Three cuttings are proposed that are in the Haverford Beds (Cutting 1) and the Slade and Redhill Formation (Cuttings 2 and 3). The proposed cutting side slopes for all are 1 vertical on 2 horizontal that will be confirmed as part of the Stage 3 GDR.

7.2.2 The ground investigation data suggest that the cuts will be excavated within the weathered and intact material. The following will need to be considered as part of the cut stability design:

a) The depth of weathered "soil" like material within the cut and if the material behaves as a cohesive or granular material. The data presented in this GIR suggests that most of the weathered material will behave as a granular material with associated higher shear strength parameters. The preliminary design will need to consider the likelihood of the weathered material behaving as a cohesive material that may impact cut slope angles and land take.

   There is a risk that the exposed weathered granular material could break down over the design life of the cut due to the material being argillaceous and weak. The preliminary design will need to consider the following that may impact cut slope angles and land take:

   - The long-term weathering behaviour of the argillaceous granular material exposed in the cut face;
   - The impact of the weathered granular material breaking down and behaving as a cohesive material.

b) The intact rock associated with the Slade and Redhill Formation was generally fractured, poorly recovered and recorded low RQDs. If cuttings 2 and 3 are excavated within the intact rock an assessment on the rock quality will be required to assess if the material will behave as a soil or an intact rock. If the material behaves as an intact rock, the impact of the bedding and fracturing orientation (and fracture strength) will need to be assessed to estimate kinematic instability.

c) There is potential for cohesive material to be present within the cut face of Cutting 1 and the impact of this lower strength material will require consideration. The intact rock likely to encountered in Cutting 1 is fractured and the cut design will need to consider the impact of the material behaving as a granular material rather than an intact rock.

d) Excavation within the existing A40 embankment is proposed for the northern cut face of Cutting 1. There is no GI data within the existing embankment and the material type forming the cut face is unknown. The existing A40 embankment side slope is 1:1.4 and it is assumed that the proposed 1:2 cut face will remain stable.

7.2.3 The groundwater monitoring has indicated that there is likely to be shallow groundwater across the site. The following are considerations for the cuttings

a) Cutting 1 - shallow groundwater struck at 1m depth and consideration for groundwater within the cut face in terms of

impact on stability and control of groundwater from the cut face will be required;

b) Cutting 2 and 3 – shallow groundwater not encountered but response zones at or just below the proposed cutting bases monitored groundwater levels close to the ground surface. The cutting design will need to consider the impact of groundwater on cut face stability and the impact on the cut formation level in terms of degradation. Provisions of cut slope and base drainage measures will be required.

Excavatability and material reuse

7.2.4 An assessment of excavatability will be provided in the Stage 3 GDR. Based on the information presented in this GIR is not anticipated that difficult excavation conditions will be encountered.

7.2.5 Within Cutting 1, there is a potential risk that intact sandstone is encountered at a higher level than anticipated that may require heavier plant to excavate.

7.2.6 The material excavated from the cuttings is likely to satisfy a Class 2 general fill (to be confirmed in the Stage 3 GDR). Consideration will need to be given to breakdown of the material during excavation, haulage and compaction. The material is comprised of mudstone that may breakdown and produce increased fines that may influence the strength parameters of the material. In the absence of site specific durability testing on the excavated material the reuse assessment will need to incorporate the durability testing conducted in similar material from the A40 LVP scheme to the east.

7.2.7 The compaction testing suggests that the weathered material from the Slade and Redhill Formation (Cutting 2 and 3) may require some form of treatment (i.e. drying) to ensure that the moisture content is reduced slightly to satisfy the MCV requirements of general fill. For example, the initial moisture content of the weathered material would result in MCVs of less than 7. The requirement of any material treatment prior to placement will need to be considered in the Stage 3 GDR. It is recommended that the testing conducted as part of the A40 LVP scheme is incorporated as pert of the Stage 3 GDR reuse assessment.

7.2.8 Made Ground may be encountered during construction associated with the existing A40. There is potential for unexpected contamination to be associated with these areas that may require off-site disposal.

7.2.9 In relation to off-site disposal, it is the intention to reuse all site won materials in the construction of earthworks. Should surplus material arise, this should be tested and classified in accordance with regulatory requirements and published guidance (such as WM3 [30]). The likelihood of encountering hazardous materials (in relation to off-site disposal) is very low.

7.2.10 The geo-environmental assessments recommend that the health and safety systems applied during the construction works should consider the potential for encountering previously unencountered materials that may be impacted by contamination. This should be in the form of a contingency plan that should establish procedures to deal with unexpected contamination. Further PPE may also be required in the area of the hydrocarbon leakage (BH09); however, this is subject to verification of the potential impact of the pollution incident.

7.3 Earthworks – embankments

7.3.1 The long-term stability of the embankments is dependent on the height of the embankments and the fill type used to form the embankment. The excavated material won from the cuts may exhibit granular or cohesive long-term strength parameters that will depend on how the material breaks down from excavation to compaction.

7.3.2 The effect of long-term weathering of the granular fills is to be considered in the Stage 3 GDR. The weathering has the potential to alter the strength properties of the fill that will affect the embankment stability. Consideration on the requirement of selecting the excavated material to ensure material less susceptible to weathering is placed towards the shoulders of the embankments may need to be considered.

7.3.3 For the high embankments (10 to 16m heights) associated with Embankment 1, Embankment 2 and the B4313 Tie in to A40 it is likely that the following measures will need to be considered to maintain the 1:2 side slope geometry at heights greater than 7.5m:

a) Granular shoulders of Class 1 fill in combination with Class 2 fill to the rear of the Class 1 shoulder;

b) Geogrids (if entirely all Class 2 general fill used to construct the embankment).

7.3.4 A shallow groundwater table is anticipated to be present across the site that in places emerges at the surface as springs. To prevent build-up of

surface water at the base of the embankments caused the shallow groundwater and embankment construction over side long ground, it is anticipated that a drainage blanket/starter layer will need to be incorporated to the base of the embankments. The drainage blanket/starter layer will need to be imported to site.

7.4 Drainage

7.4.1 Attenuation ponds are proposed that are to be partially excavated to depths of 1.5 to 4m into the existing ground. Several the ponds are located adjacent to the mainline earthworks and the preliminary design will need to consider the following:

- Stability of the pond excavation and the associated implications on the stability of the mainline earthworks adjacent to the ponds.
- The pond stability assessment will need to consider the impacts of long-term weathering on the engineering behaviour of the cut material.

7.4.2 The groundwater data suggest a relatively shallow groundwater level and lining of the ponds may be required to prevent groundwater infiltration into the pond and to ensure separation of the highway drainage from the groundwater. Uplift due to ground water pressures on the pond liners will need to be assessed.

7.4.3 Soakaway testing has generally indicated that infiltration into the natural ground is not feasible except for the Haverford Beds to the east of the site. It is recommended that infiltration into the natural ground is not allowed for in the preliminary drainage design.

7.5 Pavement

7.5.1 In-situ CBR tests were conducted as part of the GI to provide an assessment on the subgrade CBR for the purpose of pavement design.

7.5.2 A minimum in-situ CBR of 3.5% was recorded on cohesive weathered Slade and Redhill Formation. It is recommended that the preliminary pavement design is based on this CBR value for the embankments. The impact on breakdown of the placed fill will need to be considered and the impact of increased fines on the CBR value. For the cuttings the material at the cut base is to be assessed as part of the Stage 3 design

and an appropriate CBR value attributed based on the site-based information.

7.5.3 The CBR value will need to account for an equilibrium moisture content that may vary over the design life of the pavement. For example, within Cutting 2 and 3 it is interpreted that groundwater may impact the base of the cut formation causing it to "soften" over time. If drainage measures are not implemented the groundwater may impact the CBR value.

7.5.4 The proposed CBR will be assessed as part of the Stage 3 GDR.

7.6 Structures

Redstone Road Overbridge

7.6.1 The Redstone Road Overbridge is single span integral bridge structure. The current proposal is to support the abutments on shallow foundations at the base of Cutting 2.

7.6.2 The foundation type for the bridge is to be determined as part of the Stage 3 GDR.

7.6.3 Approach embankments up to around 3m in height are proposed at the crest of Cutting 2. The approach embankments will impact the stability of the cut faces. Potential for the partial removal of the weathered material towards the crest of the cutting may need to be considered.

7.6.4 The stability design of Cutting 2, incorporating the approach embankment at the crest will be considered as part of the Stage 3 GDR.

Culverts

7.6.5 Three culverts are proposed within the embankments along the scheme that are all segmental precast box structures 2m wide or 4.7m wide with wingwalls at the emergence points.

7.6.6 Two of the culverts are located below relatively high embankments (greater than 10m in height) and the following will need consideration:

a) Culvert at Ch0+420 is located on sloping ground where the overlying embankment varies in height. An assessment of differential settlement along the culvert will be required.

b) Culvert at Ch1+380 – soft Glacial Till was encountered and consideration of dig and replace may be required prior to construction of the culvert.

7.7 Geotechnical Category

7.7.1 Based on the interpretation of the ground conditions and engineering considerations presented above the project is classified as Geotechnical Category 2 in accordance with the guidelines stipulated in CD 622.

References

[1] Highways England, “Design Manual for Roads and Bridges, CD 622, Volume 4, Section 1, Part 2, Managing Geotechnical Risk,” 2019.

[2] Quantum Geotechnic Ltd, “A40 Penblewin to Redstone Cross Improvements Factual Report,” 2019.

[3] Ove Arup & Partners, “A40 Llandewi Velfrey to Penblewin Redstone Cross Improvements Supplementary Preliminary Sources Study Report,” 2017.

[4] Ove Arup & Partners, “A40 Llandewi Velfrey to Penblewin Improvements Ground Investigation Report”.

[5] Landmark, “Envirocheck Report. Site at St Clears / Sancler, Reference 358432,” 2015.

[6] British Geological Survey, “Map Sheet 228 (1:50,000) Drift and Solid Haverfordwest,” 1976.

[7] British Geological Survey, “1:10,560 map, Pembrokeshire sheet XXIX NW, 2nd Ed.,” 1907.

[8] British Geological Survey, “Geoindex Onshore,” August 2019. [Online]. Available: http://mapapps2.bgs.ac.uk/geoindex/home.html.

[9] “Memoir of the Geological Survey Sheet 228, The Geology of the South Wales Coalfield, Part XI, the Country around Haverfordwest,” 1914.

[10] “The BRITICE Glacial Mapping Project,” [Online]. Available: https://www.sheffield.ac.uk/geography/staff/clark_chris/britice_v2/index .

[11] WYG, “A40 Llandewi Velfrey to Penblewin Improvements, Ground Investigation Factual Report,” 2017.

[12] “Lle, Welsh Government Data Portal,” [Online]. Available: http://lle.gov.wales.

[13] “Cambridge Air Photos,” [Online]. Available: https://www.cambridgeairphotos.com/ .

[14] Ove Arup & Partners, “Review of Mining Instability in Great Britain, for the Department of the Envrionment,” 1999.

[15] Coal Authority, [Online]. Available: https://www2.groundstability.com/.

[16] Cadw, “Designated Historic Assets Viewer. Designated Historic Asset Descriptive Information, The Welsh Historic Environment Service (Cadw),

DATE May 2019, licensed under the Open Government Licence http://www.nationalarchiv," [Online]. Available: https://cadw.gov.wales/historicenvironment/recordsv1/cof-cymru/?lang=en.

[17] Cadw, "Redstone Cross Round Barrows Scheduled Monument Report," [Online]. Available: https://cadwpublic-api.azurewebsites.net/reports/sam/FullReport?lang=en&id=2039.

[18] Welsh Government, "Integrated Roads Information System," [Online].

[19] Ove Arup & Partners, "ES Chapter 7 Road Drainage and Water Environment, A40PRC-ARP-EAC-SWI-RP-LE-0002," Arup, Cardiff, 2020.

[20] Natural Resources Wales, [Online]. Available: https://naturalresources.wales/ . [Accessed October 2019].

[21] CIRIA, "C681 Unexploded Ordnance (UXO), A guide for the construction industry," 2009.

[22] G. E. Barnes, "Soils Mechanics: Principles and Practice," Macmillan Press, Basingstoke, 2000.

[23] M. A. Stroud, "The Standard Penetration Test – Its Application and Interpretation," 1974.

[24] British Standards Institute, "BS 8004:2015 Code of practice for foundations," BSI, 2015.

[25] C. Clayton, "CIRIA 143: The Standard Penetration Test (SPT): Methods and Use," CIRIA, 1995.

[26] British Standards Institute, "BS 8002:2015 Code of practice for earth retaining structures," BSI, London, 2015.

[27] E. Hoek and J. W. Bray, "Rock Slope Engineering," CRC, London, 1981.

[28] British Standards Institute, "BS 8004:1986 Code of practice for foundations," BSI, 1986.

[29] BRE Special Digest, "(third edition) Concrete in aggressive ground.," 2005.

[30] N. R. Wales, "Waste Classification: Guidance on the classification and assessment of waste (1st Edition v1.1) Technical Guidance WM3," Natural Resources Wales , 2018.

[31] Defra, "Environmental Protection Act 1990: Part 2A, Contaminated Land Statutory Guidance," April 2012.

[32] Defra, “The Water Framework Directive (Standards & Classification) Directions (England and Wales), Department of Environment Food and Rural Affairs,” 2015.

[33] E. Agency, “Remedial Targets Methodology, Hydrogeological Risk Assessment for Land Contamination,” 2006.

[34] S. N. N. a. E. Waste Classification Technical Guidance WM3, “Waste classification, Guidance on the classification and assessment of waste (1st Edition v1.1),” 2018.

[35] Ove Arup & Partners, “Revised Annex A to Preliminary Sources Study Report,” 2019.

[36] Defra, “Assessing Risks from Land Contamination - A Proportionate Approach, Soil Guideline Values: The Way Forward, CLAN 06/2006,” 2006.

[37] Defra, “Development of Category 4 Screening levels for assessment of land affected by contamination, SP1010, Final Project report (Revision 2),” 2014.

[38] Paul Nathaniel et al., “The LQM/ CIEH S4ULs for Human Health Risk Assessment, Version 1.0,,” 2015.

[39] British Standards Institute, “BS EN 1997-1:2007 Eurocode 7 Geotechnical Design,” 2014.

[40] Costain, Atkins and Cresswell Associates, “A40 Trunk Road Penblewin to Slebach Park Improvement Geotechnical Report 5034100/GI/GR/RT006,” 2007.

[41] T. Geotechnical, “A40 Robeston Wathen Bypass, Ground Investigation Factual Report Volumes 1 and 2, 7631,” 1996.

[42] Mott MacDonald, “Preliminary Sources Study Report, Revision A,” 2016.

[43] British Standards Insitute , BS EN 1997-2:2007 – Eurocode 7. Geotechnical Design. Ground Investigation and Testing., 2007.

[44] British Standards Insitute, BS 1377 – Methods for Test for Soils for Civil Engineering Purposes.

[45] British Standards Institute, BS EN 1097 - Tests for mechanical and physical properties of aggregates, 2008.

[46] British Standards Institute, BS 5930 – Code of Practice for Ground investigations, 2015.

[47] Ove Arup & Partners, “A40 Llanddewi Velfrey to Penblewin Geotechnical Design Report (A40LVP-ARP-HGT-SWI-RP-C-0002),” Ove Arup & Partners, Cardiff, 2017 .

[48] British Standards Institute, “BS EN 1997-2:2007 Eurocode 7 Geotechnical Design,” 2010.

[49] Z. T. Bieniawski, “Estimating the strength of rock materials. Journal of the South African institute of mining and metallurgy,” 1974.

[50] RocScience, “Roclab,” [Online]. Available: https://www.rocscience.com/. [Accessed June 2019].

[51] Stroud, “The Standard Penetration Test: Its Application and Interpretation,” Thomas Telford, London, 1989.

[52] Ove Arup & Partners, “A40 Penblewin to Redstone Cross Improvements Statement of Intent,” 2019.

[53] Highways England, “Design guidance for road pavement foundations,” Highways England, London, 2009.

Figures

Drawing 1 – Site Location Plan

Drawing 2– Geotechnical Features and Constraints Plan

Drawing 3 - Ground Investigation Location Plan (West Section)

Drawing 4 - Ground Investigation Location Plan (East Section)

Figure 1 – Long Section West (Ch 0+000 to 0+800)

Figure 2 – Long Section East (Ch 0+800 to 1+760)

Figure 3 - Long Section Southern Side Road

Figure 4 – Cross Section Cutting 1 (Ch 0+180)

Figure 5 – Cross Section Embankment 1 (Ch 0+460)

Figure 6 – Cross Section Cutting 2 (Ch 0+600)

Figure 7 - Cross Section Embankment 2a (Ch 0+910)

Figure 8 – Cross Section Embankment 2b (Ch 1+300)

Figure 9 – Cross Section Cutting 3 (Ch 1+560)

Figure 10 – Southern Side Road Cross Section

Figure 11 – Groundwater Monitoring Results

Figure 12 - Natural moisture content vs depth – Glacial Till

Figure 13 - Atterberg Limits (Casagrande Chart) – Glacial Till

Figure 14 - Atterberg Limits and natural moisture content vs depth – Glacial Till

Figure 15 - Particle size distribution – Glacial Till

Figure 16 - Standard Penetration Test vs depth – Glacial Till

Figure 17 - Undrained shear strength vs depth (triaxial testing) – Glacial Till

Figure 18 - Oedometer plots – Glacial Till

Figure 19 - Atterberg Limits and natural moisture content vs depth – weathered and intact Haverford Beds

Figure 20 - Atterberg Limits (Casagrande Chart) – weathered and intact Haverford Beds

Figure 21 - Particle size distribution – weathered and intact Haverford Beds

Figure 22 - Dry density vs moisture content (compaction test) - weathered Haverford Beds

Figure 23 - Standard Penetration Test vs depth – intact Haverford Beds

Figure 24 - Point load index Is(50) vs depth - intact Haverford Beds

Figure 25 - Natural moisture content vs depth – weathered Slade and Redhill Formation

Figure 26 - Atterberg Limits (Casagrande Chart) – weathered and intact Slade and Redhill Formation

Figure 27 - Atterberg Limits and natural moisture content vs depth – weathered Slade and Redhill Formation

Figure 28 - Particle size distribution – weathered Slade and Redhill Formation

Figure 29 - Dry density vs moisture content (compaction test) - weathered Slade and Redhill Formation

Figure 30 - Standard Penetration Test vs depth – weathered and intact Slade and Redhill Formation

Figure 31 - Shear box tests - weathered and intact Slade and Redhill Formation

Figure 32 - RQD vs depth – intact Slade and Redhill Formation

Figure 33 - Natural moisture content vs depth – intact Slade and Redhill Formation

Figure 34 - Particle size distribution – intact Slade and Redhill Formation

Figure 35 - Dry density vs moisture content (compaction test) - intact Slade and Redhill Formation

Figure 36 - Point load index Is(50) vs depth - intact Slade and Redhill Formation

Figure 37 - UCS from point load tests vs depth – intact Slade and Redhill Formation

Figure 38 - RQD vs depth – intact Dicranograptus Beds

Figure 39 - Natural moisture content vs depth – weathered and intact Dicranograptus Beds

Figure 40 - Atterberg Limits (Casagrande Chart) – weathered and intact Dicranograptus Beds

Figure 41 - Atterberg Limits and natural moisture content vs depth – weathered and intact Dicranograptus Beds

Figure 42 - Particle size distribution – weathered and intact Dicranograptus Beds

Figure 43 - Standard Penetration Test vs depth - weathered and intact Dicranograptus Beds

Figure 44 - UCS from point load tests vs depth – intact Dicranograptus Beds

Figure 45 - RQD vs depth – intact Llandeilo Limestone Formation

Figure 46 - Particle size distribution – weathered Llandeilo Limestone Formation

Figure 47 - Standard Penetration Test vs depth - weathered and intact Llandeilo Limestone Formation

CHAINAGE (m)

0 100 200 300 400 500 600 700 800

ELEVATION (mOD)

100 95 90 85 80 75 70

RCETP01 (34.8)
RCETP02 (3.7)
RCETP03 (2.4)
RCETP04 (2.8)
RCEBH15 (4.7)
RCEBH01 (5.7)
RCEBH02 (-11.9)
RCEDS02
RCEDS01
RCEBH16 (-4.9)
RCEDS05 (-9.7)
RCETP19 (39.0)
RCETP03 (3.6)
RCETP05 (-2.1)
RCEBH03 (-18.6)
RCEBH12 (19.7)
RCETP18 (2.7)
RCEBH14 (-6.2)
RCETP06 (1.1)
RCEBH04 (-15.4)
RCETP07 (-8.6)

20min Seepage
8min Medium water ingress at
20min
20min
20min Medium flow
20min Fast water strike at 1.6mbgl rising to 0.90m
SPIE
Seepage at 2.5mbgl

Cutting 1 | Embankment 1 | Cutting 2

Existing Ground Surface

SCALE 1:200V 1:2222H @ A3-L

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Made by Arcdian Teague on 24-Feb-20

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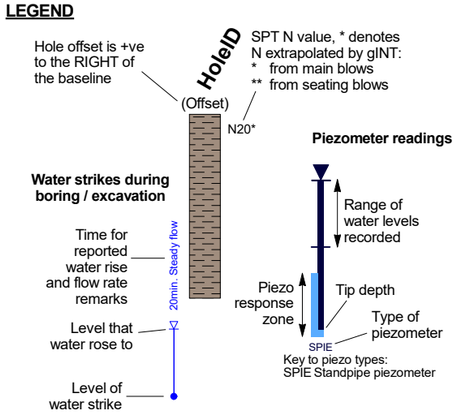

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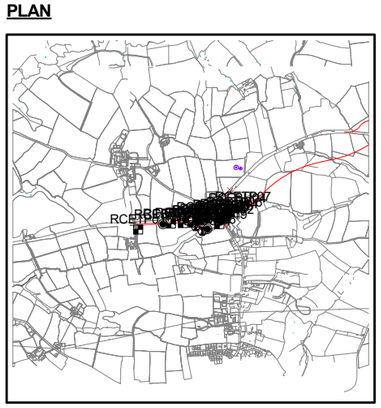

COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Weathered Haverford Beds Formation [WHB]
- Slade and Redhill Formation [SR]
- Haverford Beds Formation [HB]

MATERIALS

- SILT
- Clayey GRAVEL
- SANDSTONE
- TOPSOIL
- Clayey sandy GRAVEL
- MUDSTONE
- SILTSTONE
- Sandy CLAY
- Sandy gravelly CLAY
- Gravelly CLAY
- COBBLES
- CLAY
- Sandy gravelly cobbly CLAY
- Silty sandy gravelly CLAY

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION 0+000 TO 0+800

263826-00

FIGURE 1

DISTANCE ALONG BASELINE (m)

800 900 1,000 1,100 1,200 1,300 1,400 1,500 1,600 1,700 1,800

ELEVATION (mOD)

95 90 85 80 75 70 65 60

Refer to Figure 7 for clarity on exploratory hole references

RCEDS08 (-43.3)
RCEDS09 (-24.0)
RCEBH05 CR
RCEBH08
RCEBH06 (-3.9)
RCETP09 (-14.2)
RCEBH07 (-5.1)
RCETP10 (-15.8)
RCEBH08 (-2.9)
RCETP11 (-7.8)
RCETP12 (14.3)
RCEBH09 (-17.4)
RCESA12 (24.0)
RCETP13 (-3.2)
RCEBH10 (-8.3)
RCETP14 (-4.6)
RCEBH11 (1.1)
RCETP15 (3.6)

Main seepages from RCEDS08 at 0.8mbgl
20min Medium water ingress at 6.2mbgl
20min Medium Ingress from 4.7mbgl
20min Slow water ingress at 2.3mbgl
Seepage at 0.25mbgl
Seepage at 0.4mbgl
20min Medium
20min Slow water ingress at 3.0mbgl
20min Fast
Seepage at 2.0mbgl
20min Medium
Seepage at 1.05mbgl
SPIE

Embankment 2a | Embankment 2b | Cutting 3

Proposed Highway
Existing Ground Surface

SCALE 1:200V 1:2778H @ A3-L

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LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID (Offset) N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

20min. Steady flow

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Piezo response zone

Tip depth

Type of piezometer

SPIE

Key to piezo types:
SPIE Standpipe piezometer

PLAN

COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Weathered Llandeilo Limestone Formation [WLL]
- Weathered Dicranograptus Beds Formation [WDB]
- Slade and Redhill Formation [SR]
- Llandeilo Limestone Formation [LL]
- Glacial Deposits [GTD]
- Dicranograptus Beds Formation [DB]

MATERIALS

- TOPSOIL
- Sandy gravelly CLAY
- SILTSTONE
- Sandy gravelly cobbly bouldery CLAY
- Clayey sandy GRAVEL
- MUDSTONE
- Clayey GRAVEL
- Sandy gravelly cobbly CLAY
- Gravelly CLAY
- Sandy gravelly organic CLAY
- Silty sandy gravelly peaty CLAY
- Silty sandy GRAVEL
- Silty cobbly GRAVEL

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION 0+800 TO 1+760

263826-00

FIGURE 2

ARUP gINT v8.30.003
Made by Alastair Teague on 24-Feb-20

CHAINAGE (m)

0 20 40 60 80 100 120 140 160 180 200

ELEVATION (mOD)

100 95 90 85 80 75 70

RCEDS03
(16.4)

RCEDS04
(4.0)

RCEBH16
(-9.9)
N500
N750
N462
N638
N2000
SPIE

RCETP19
(-6.9)

RCEBH03
48.7
N375
N857
N3000
N3000
N3000
20min Seepage
SPIE

RCETP05
(-40.9)

Existing Ground Surface

SCALE 1:200V 1:600H @ A3-L

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Made by Adrian Hague on 24-Feb-20

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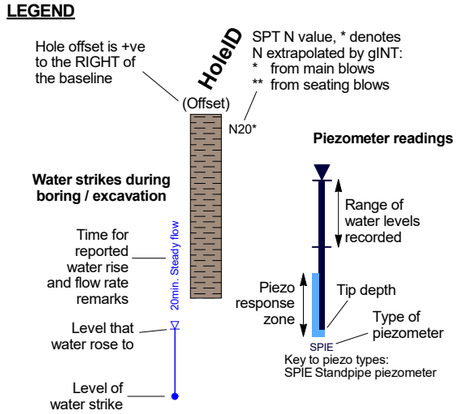

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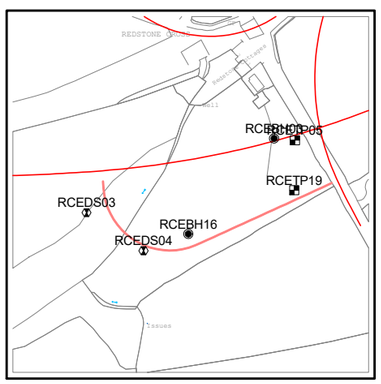

COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Slade and Redhill Formation [SR]

MATERIALS

- TOPSOIL
- Clayey sandy GRAVEL
- MUDSTONE
- Sandy CLAY
- Clayey GRAVEL
- Silty sandy gravelly CLAY

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION SOUTHERN SIDE ROAD

263826-00

FIGURE 3

DISTANCE ALONG BASELINE (m)

0 10 20 30 40 50 60 70 80 90

ELEVATION (mOD)

94 92 90 88 86 84 82 80 78 76

RCEBH01

(-0.1)

N

N167*

N

N282*

N

N259*

N

N484*

N750*

N1000*

SPIE

Proposed Highway

Existing Ground Surface

SCALE 1:100V 1:250H @ A3-L

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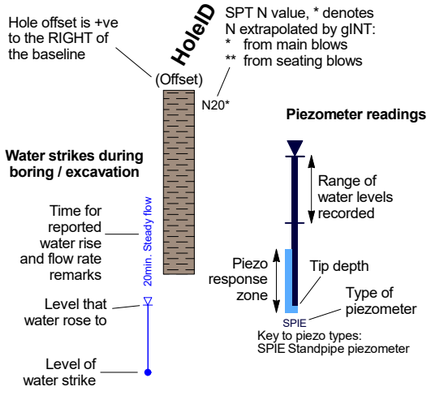

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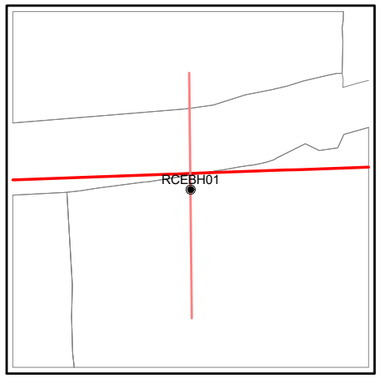


COLOUR LEGEND

- Topsoil [TOP]
- Weathered Haverford Beds Formation [WHB]
- Haverford Beds Formation [HB]

MATERIALS

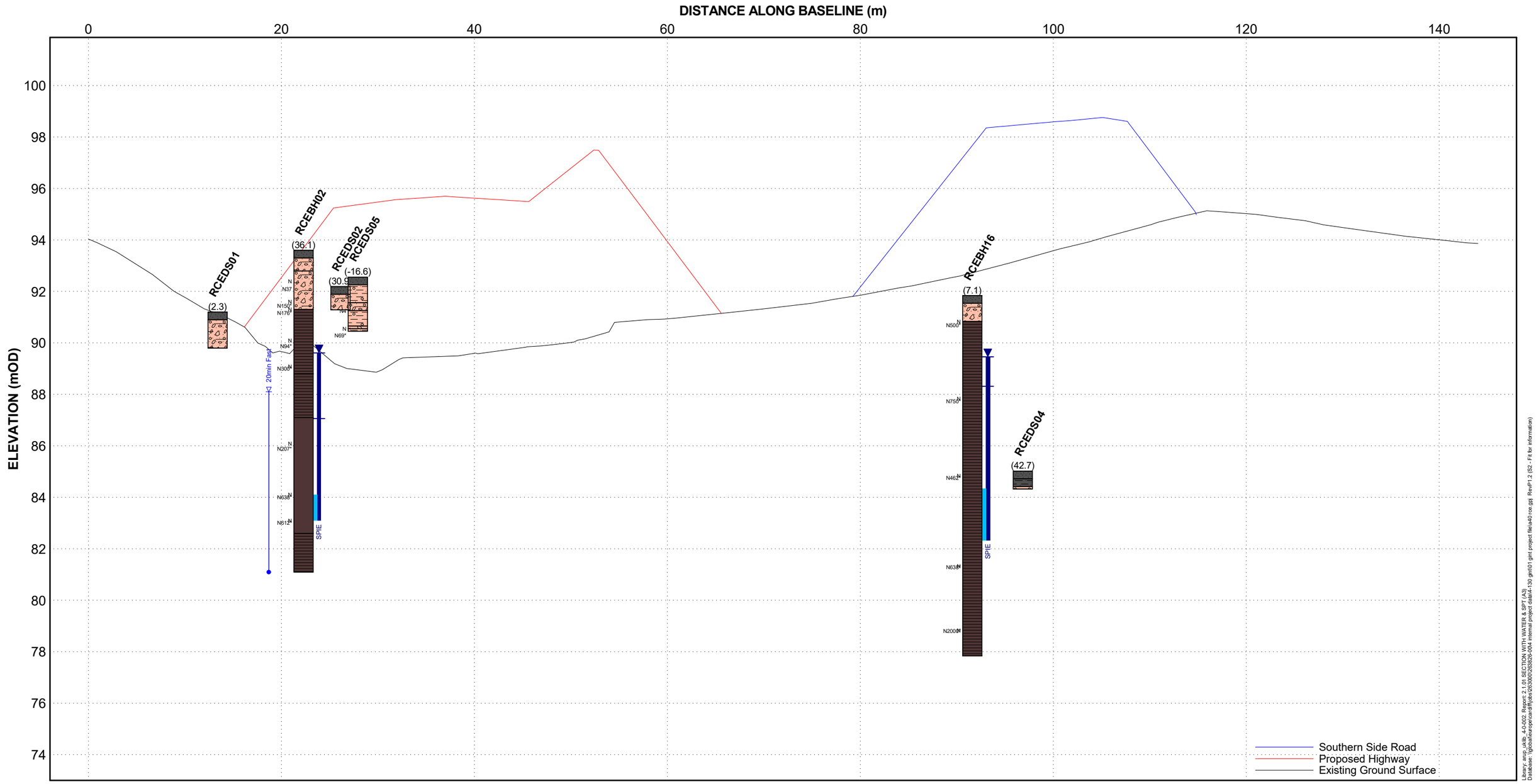
- SILT
- Clayey GRAVEL
- SANDSTONE

ARUP gINT v8.3.30.003
Made by Adrian Hogue on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION CUTTING 1 (0+180)

263826-00

FIGURE 4



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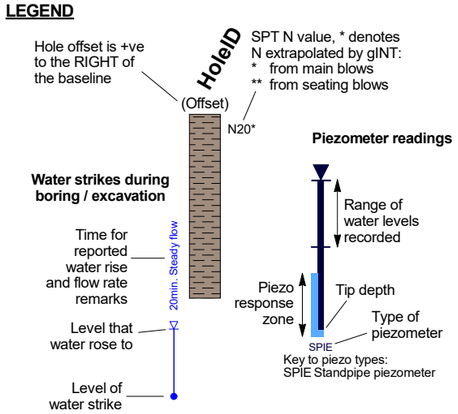
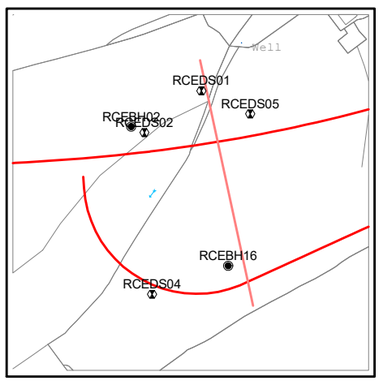
Made by Adrian Hodge on 24-Feb-20

LEGEND



PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Slade and Redhill Formation [SR]

MATERIALS

- TOPSOIL
- COBBLES
- Clayey sandy GRAVEL
- MUDSTONE
- Sandy CLAY
- Clayey GRAVEL
- Sandy gravelly CLAY
- Gravelly CLAY

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION EMBANKMENT 1 (0+460)

263826-00

FIGURE 5

DISTANCE ALONG BASELINE (m)

0 10 20 30 40 50 60 70

ELEVATION (mOD)

102 100 98 96 94 92 90 88 86

RCEBH13 (7.1)
RCEBH03 (46.0)
RCEBH14 (-40.1)
RCETP18 (-10.2)
RCETP05 (32.1)
RCEBH12 (-1.2)

N333 N357 N333 N968 N1667 N1875
N375 N857 N3000 N3000 N3000
N50* N30* N1364
N772 N56* N50* N300* N219* N326 N968

8min Medium water ingress at 9.0mbgl
20min Seepage
20min
SPIE

Proposed Highway
Existing Ground Surface

SCALE 1:100V 1:200H @ A3-L

Library: arup_uk\B_a-0-002_Report 2_1 01 SECTION WITH WATER & SPT (A3)
Database: \\global.arup.com\dfs\projects\263826\263826-00\4 Internal project data\4-1-50 gint\01 gint project file\a40 rce.gpj RevP1.2 (S2 - Fit for information)

LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID (Offset) N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Piezo response zone

SPIE

Key to piezo types:
SPIE Standpipe piezometer

Water strikes during boring / excavation

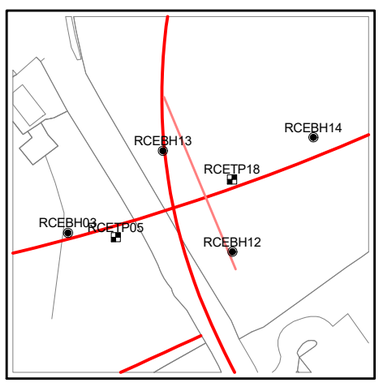
Time for reported water rise and flow rate remarks

20min. Steady flow

Level that water rose to

Level of water strike

PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Slade and Redhill Formation [SR]

MATERIALS

- TOPSOIL
- Clayey sandy GRAVEL
- MUDSTONE
- SILTSTONE
- Silty sandy gravelly CLAY
- Clayey GRAVEL

ASUP: gINT v8.30.003
Made by Adrian Tingle on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION CUTTING 2 (0+600)

263826-00

FIGURE 6

DISTANCE ALONG BASELINE (m)

0 10 20 30 40 50 60 70 80 90 100

ELEVATION (mOD)

94 92 90 88 86 84 82 80 78 76 74 72 70 68

RCETP08 RCEBH05 CP RCEBH06 RCEBH05 ROT RCEDS06a RCEDS06b RCEDS07 RCEDS10

(23.5) (38.5) (34.2) (29.9) (32.9) (24.9) (30.3)

20.1

Many seepages from 1.2 to 2.9mbgl

20min Medium water ingress at 12.2mbgl

SPIE

N N27 N N38 N N120 N N26 N N29 N N60 N N300

Proposed Highway
Existing Ground Surface

SCALE 1:150V 1:300H @ A3-L

Library: arup_uklib_4-0-002, Report: 2.1.01 SECTION WITH WATER & SPT (A3)
Database: \\global.arup.com\staff\dfs\jobs\263000\263826\04 Internal project data\4-130 gint\01 gint project file\a40 rce.gpj RevP1.2 (S2 - Fit for information)

LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID

(Offset)

N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

20min, Steady flow

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Piezo response zone

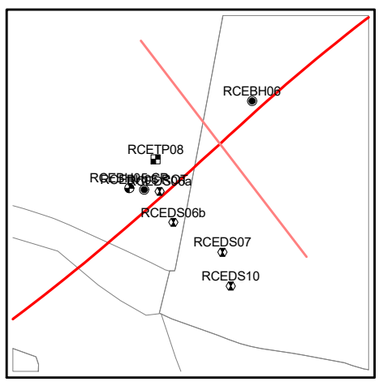
Tip depth

Type of piezometer

SPIE

Key to piezo types:
SPIE Standpipe piezometer

PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Llandeilo Limestone Formation [WLL]
- Weathered Dicranograptus Beds Formation [WDB]
- Llandeilo Limestone Formation [LL]
- Glacial Deposits [GTD]
- Dicranograptus Beds Formation [DB]

MATERIALS

- TOPSOIL
- Sandy gravelly CLAY
- SILTSTONE
- Sandy gravelly cobbly bouldery CLAY
- Clayey sandy GRAVEL
- MUDSTONE
- Clayey GRAVEL

ARUP_gINT_v8i_30.003
Made by Arup on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION EMBANKMENT 2A (0+910)

263826-00

FIGURE 7

DISTANCE ALONG BASELINE (m)

0 10 20 30 40 50 60 70 80 90 100

ELEVATION (mOD)

86 84 82 80 78 76 74 72 70 68 66 64 62 60

RCETP11 (38.0) (0.0) 20min Seep 20min Slow water ingress at 3.0mbgl N N27 N N43 N N176 N N176 N N44 N N857 N N1200 N N1200 SPIE

RCEBH09

RCEBH08 (52.8) 20min Fast N N31 N N44 N N107 N N30 N N35 N N462 N N353 N N200 SPIE

RCETP12 (17.6) Seepages at 2.7mbgl

RCESA12 (-37.0)

Proposed Highway
Existing Ground Surface

SCALE 1:150V 1:300H @ A3-L

Library: arup_uklib_4-0-002, Report 2.1.01 SECTION WITH WATER & SPT (A3)
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 Internal project data\4-13g gint\01 gint project file\a40 rce.gpj RevP1.2 (S2 - Fit for information)

LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID (Offset) N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

20min. Steady flow

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Piezo response zone

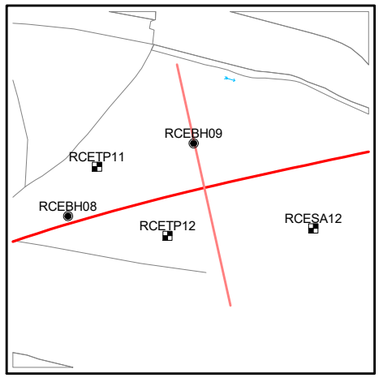
Tip depth

Type of piezometer

SPIE

Key to piezo types:
SPIE Standpipe piezometer

PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Dicranograptus Beds Formation [WDB]
- Glacial Deposits [GTD]
- Dicranograptus Beds Formation [DB]

MATERIALS

- TOPSOIL
- Sandy gravelly CLAY
- Sandy gravelly cobbly CLAY
- Gravelly CLAY
- MUDSTONE
- Sandy gravelly organic CLAY
- Clayey sandy GRAVEL

ARUP gINT v8.30.003
Made by Adrian Hodge on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION EMBANKMENT 2B (1+300)

263826-00

FIGURE 8

DISTANCE ALONG BASELINE (m)

ELEVATION (mOD)

RCEBH10 (82.0) N968 N3000 N6000 N4286* N3000 N3000 SPIE

RCETP14 (50.6)

Seepage at 2.2mbgl

RCEBH11 (-7.1) N545 N6000 N3000 N7500* N6000 SPIE

RCETP15 (-45.6)

20min Medium

Proposed Highway

Existing Ground Surface

SCALE 1:150V 1:300H @ A3-L

Library: arup_uklib_4-0-002_Report 2.1.01 SECTION WITH WATER & SPT (A3)
Database: \\global.arupnet.com\files\BSB\00\263826-00\4 Internal project data\4-1 Gis gint\01 gint project file\a40 rce.gpj RocP1.2 (S2 - Fit for information)

LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID (Offset) N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Piezometer readings

Range of water levels recorded

Tip depth

Type of piezometer

Piezo response zone

SPIE

Key to piezo types:
SPIE Standpipe piezometer

Water strikes during boring / excavation

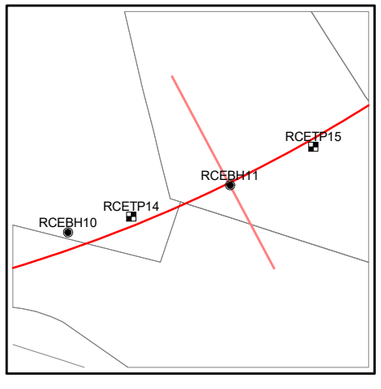
Time for reported water rise and flow rate remarks

20min. Steady flow

Level that water rose to

Level of water strike

PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Slade and Redhill Formation [SR]

MATERIALS

- TOPSOIL
- SILTSTONE
- MUDSTONE
- Clayey sandy GRAVEL
- Silty cobbly GRAVEL

ARUP gINT v6.30.003
Made by Adrian Hogue on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION CUTTING 3 (1+560)

263826-00

FIGURE 9

DISTANCE ALONG BASELINE (m)

ELEVATION (mOD)

Southern Side Road
Proposed Highway
Existing Ground Surface

SCALE 1:133V 1:444H @ A3-L

LEGEND

Hole offset is +ve to the RIGHT of the baseline

HoleID (Offset) N20*

SPT N value, * denotes N extrapolated by gINT:
* from main blows
** from seating blows

Water strikes during boring / excavation

Time for reported water rise and flow rate remarks

20min. Steady flow

Level that water rose to

Level of water strike

Piezometer readings

Range of water levels recorded

Piezo response zone

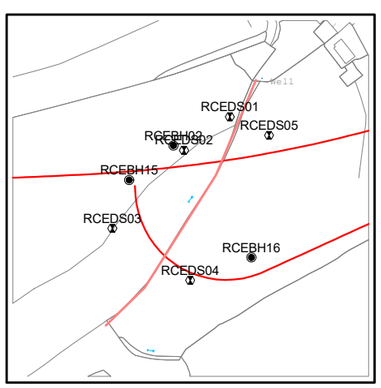
Tip depth

Type of piezometer

SPIE

Key to piezo types:
SPIE Standpipe piezometer

PLAN



COLOUR LEGEND

- Topsoil [TOP]
- Weathered Slade and Redhill Formation [WSR]
- Slade and Redhill Formation [SR]

MATERIALS

- TOPSOIL
- COBBLES
- Clayey sandy GRAVEL
- MUDSTONE
- Sandy CLAY
- Clayey GRAVEL
- Sandy gravelly CLAY
- Gravelly CLAY

A40 REDSTONE CROSS IMPROVEMENTS GEOLOGICAL CROSS SECTION SOUTHERN SIDE ROAD

263826-00

FIGURE 10

Library: arup_uk\B_4-0-0\02. Report\2.1.01 SECTION WITH WATER & SPT (A3).
Database: \\globalarcapps\cardiff\jobs\263800\263826\00\4 internal project data\4-1-00 gint\01 gint project file\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

ARUP gINT v8.30.003
Made by Adrian Hodge on 24-Feb-20

DAYS SINCE 9 SEPTEMBER 2019

PIEZOMETRIC DEPTH (m)

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90

0 2 4 6 8 10 12 14 16

Oct Nov Dec

- RCEBH05 CP
- RCEBH01
- RCEBH02
- RCEBH03
- RCEBH04
- RCEBH06
- RCEBH07
- RCEBH08
- RCEBH09
- RCEBH10
- RCEBH11
- RCEBH12
- RCEBH13
- RCEBH14
- RCEBH15
- RCEBH16

| None | None

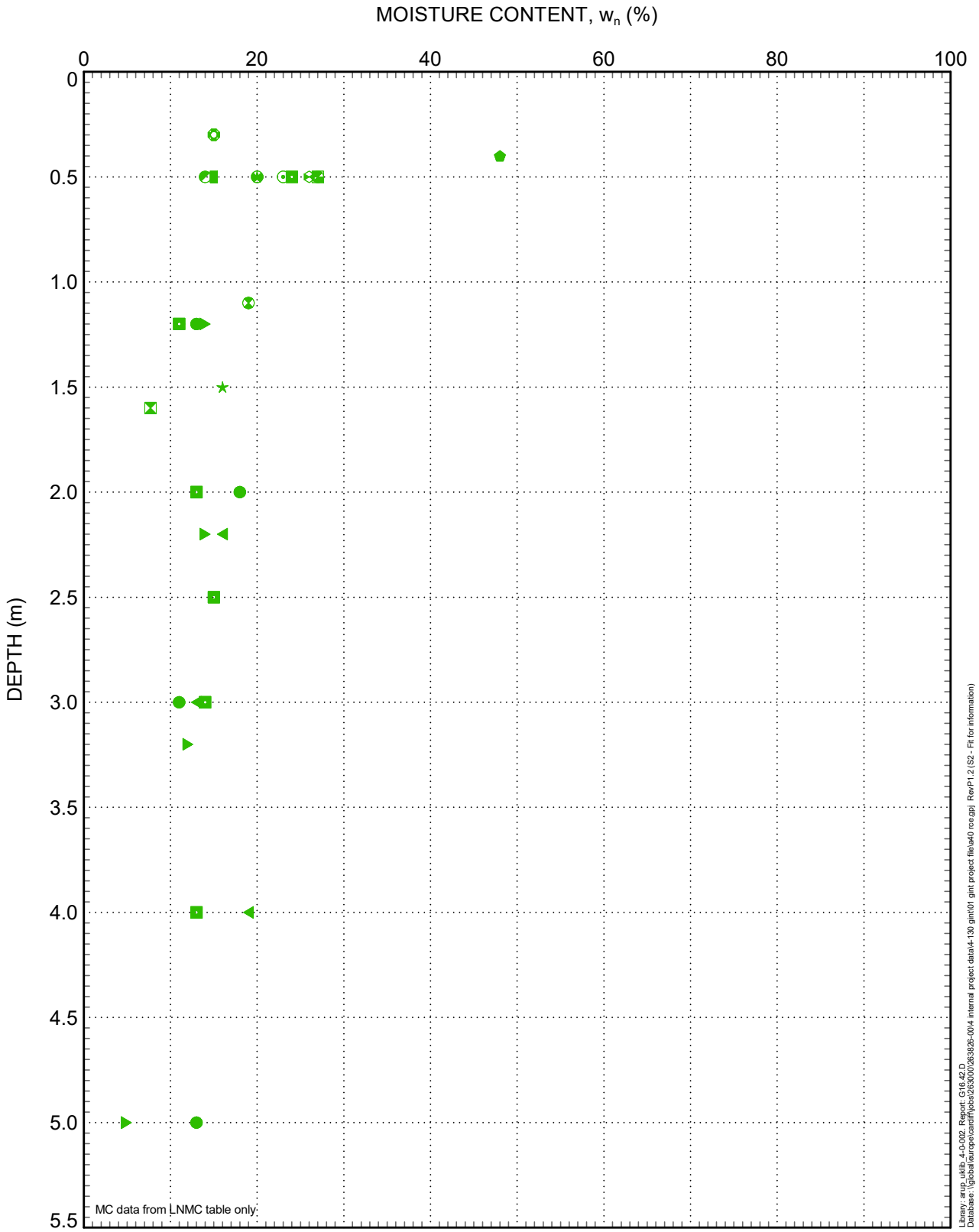
ARUP - gINT_v8.30.003
Made by Adrian Teague on 24-Feb-20

Library: arup_uk0h_4-0-0#2, Report: GRB_01_P+2D
Dataset: \\global.arup.com\projects\GB\263000\263826-00\4 internal project data\4-130 gint\01 gint project file\a40 rce.gpj Rev-P1.2 (S2 - Fit for information)

A40 REDSTONE CROSS IMPROVEMENTS
PIEZOMETRIC DATA VS TIME

263826-00

FIGURE 11



Glacial Deposits (GTD)
RCEBH05 CP
RCEBH06
RCEBH07
RCEBH08
RCEBH09
RCEDS06a
RCEDS07
RCEDS08
RCEDS10
RCESA12
RCETP08
RCETP09
RCETP10
RCETP11
RCETP12
| None | None

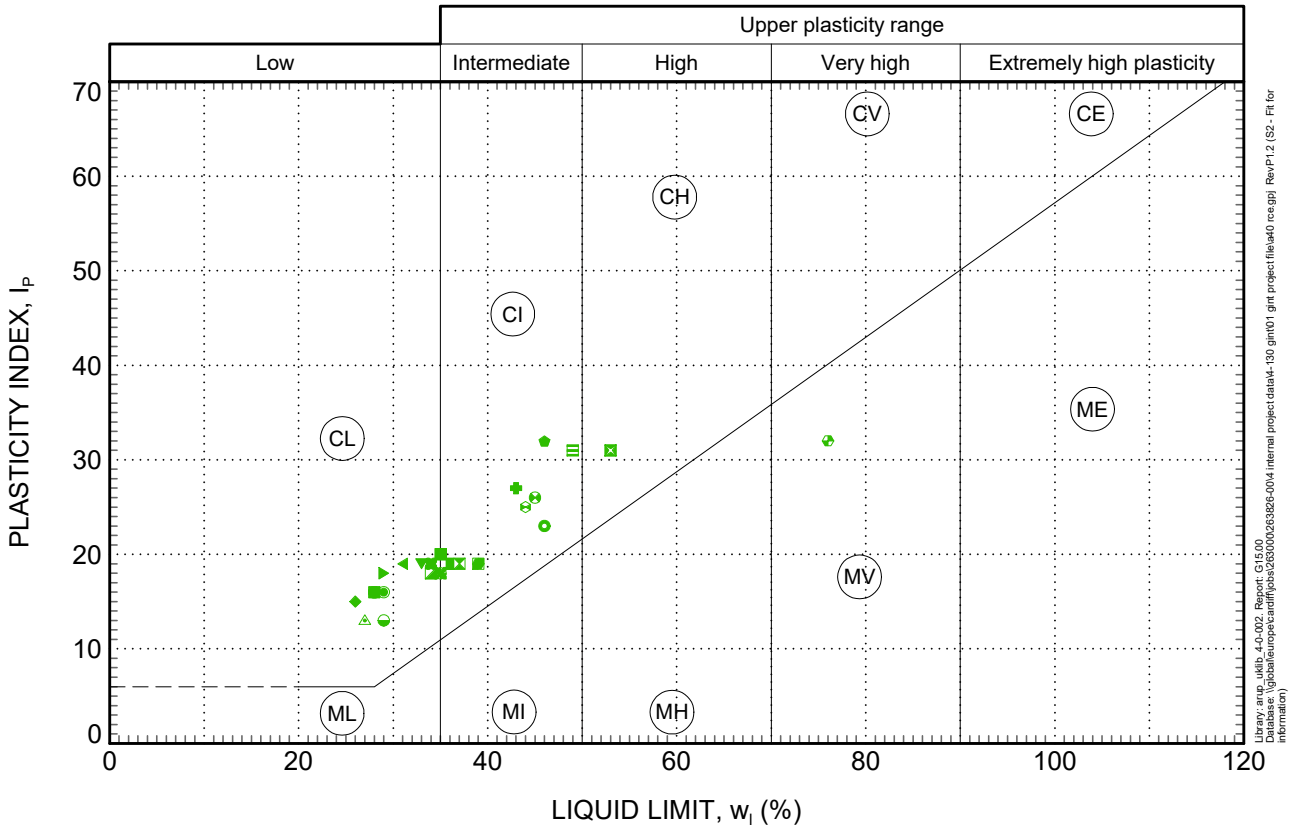
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

Library: arup_uklib_4-0-002, Report: G16_42_D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj, RevP1.2 (S2 - Fit for information)

A40 REDSTONE CROSS IMPROVEMENTS
NATURAL MOISTURE CONTENT
GLACIAL DEPOSITS

263826-00

FIGURE 12



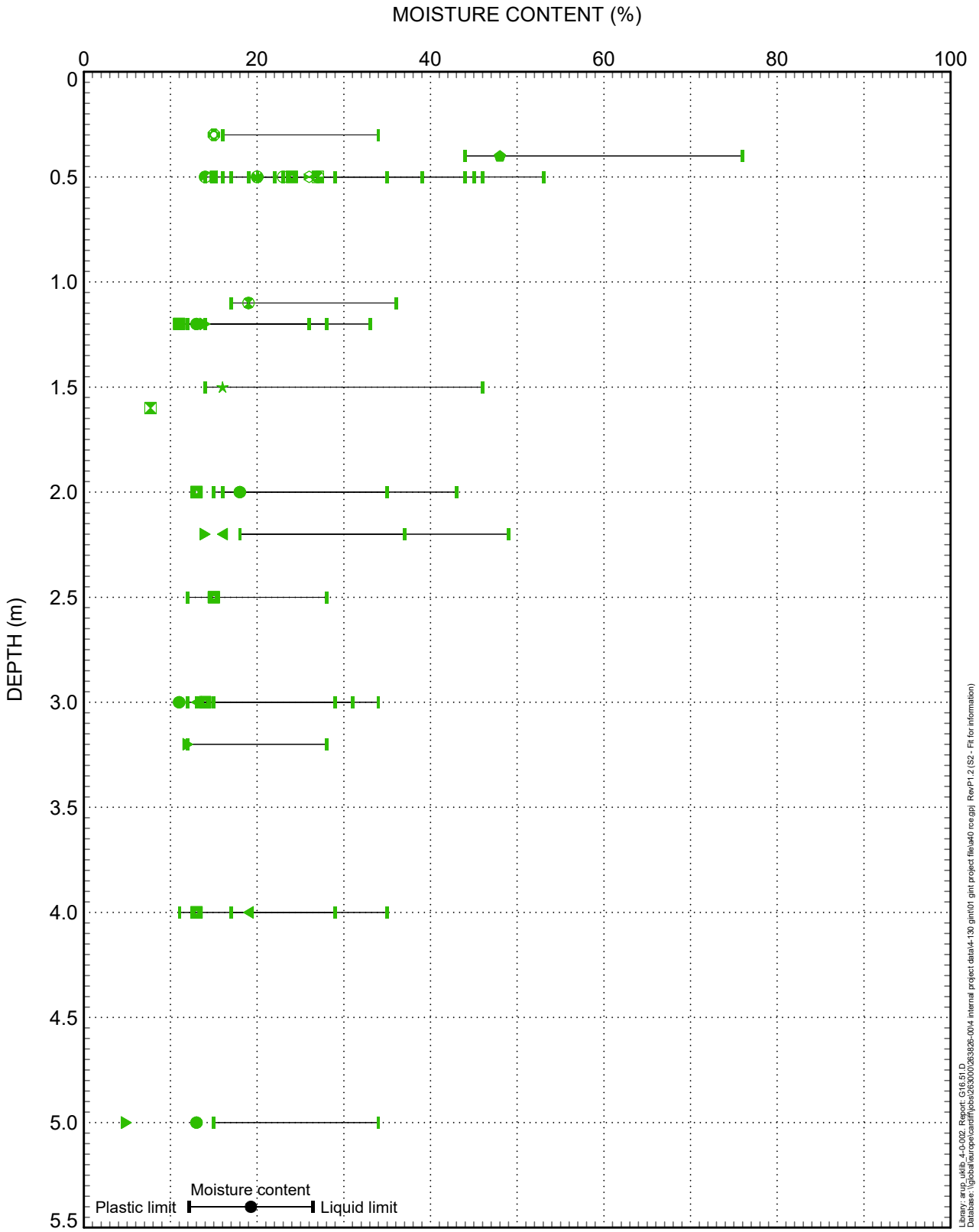
- Glacial Deposits (GTD)
- RCEBH05 CP, 1.20m, 4
- RCEBH05 CP, 2.00m, 8
- RCEBH05 CP, 3.00m, 12
- RCEBH05 CP, 5.00m, 19
- RCEBH06, 0.50m, 2
- RCEBH06, 1.20m, 4
- RCEBH06, 2.00m, 8
- RCEBH06, 2.50m, 11
- RCEBH06, 3.00m, 12
- RCEBH06, 4.00m, 16
- RCEBH07, 2.20m, 8
- RCEBH07, 3.00m, 12
- RCEBH07, 4.00m, 17
- RCEBH08, 1.20m, 4
- RCEBH08, 2.20m, 7
- RCEBH08, 3.20m, 11
- RCEDS06a, 0.40m, 1
- RCEDS07, 0.50m, 1
- RCEDS08, 0.50m, 1
- RCEDS10, 0.30m, 1
- RCESA12, 0.50m, 2
- RCETP08, 0.50m, 3
- RCETP09, 0.50m, 3
- RCETP09, 1.50m, 5
- RCETP10, 0.50m, 3
- RCETP11, 0.50m, 3
- RCETP12, 0.50m, 3
- RCETP12, 1.10m, 4

A40 REDSTONE CROSS IMPROVEMENTS PLASTICITY CHART GLACIAL DEPOSITS

263826-00

FIGURE 13

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20



Library: arup_uklib_4-0-002_Report: G16.51.D
Database: \\globaleurope\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

- Glacial Deposits (GTD)
- RCEBH05 CP
- RCEBH06
- RCEBH07
- RCEBH08
- RCEBH09
- RCEDS06a
- RCEDS07
- RCEDS08
- RCEDS10
- RCESA12
- RCETP08
- RCETP09
- RCETP10
- RCETP11
- RCETP12

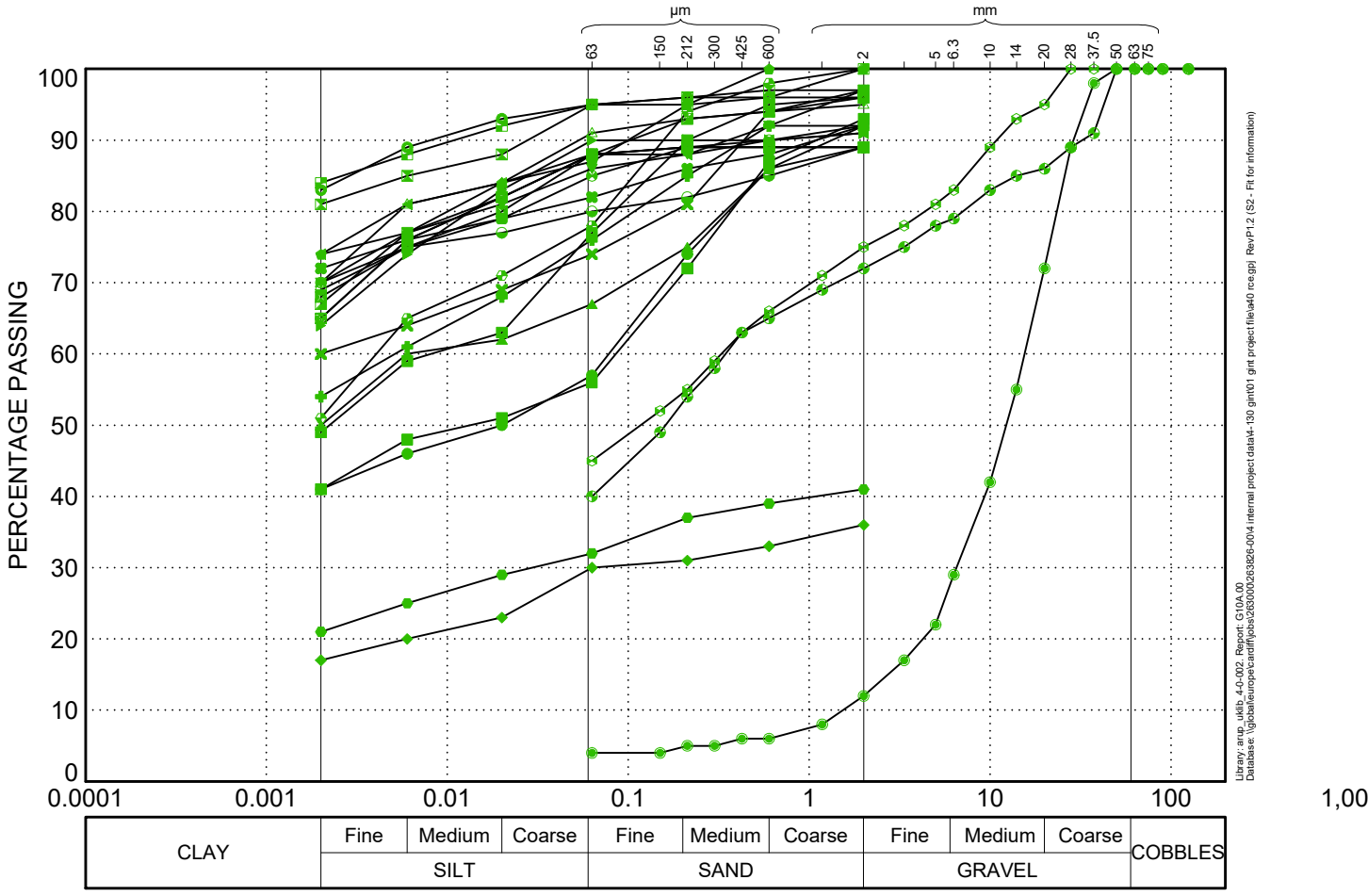
| None | None

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS
ATTERBERG LIMITS
GLACIAL DEPOSITS

263826-00

FIGURE 14



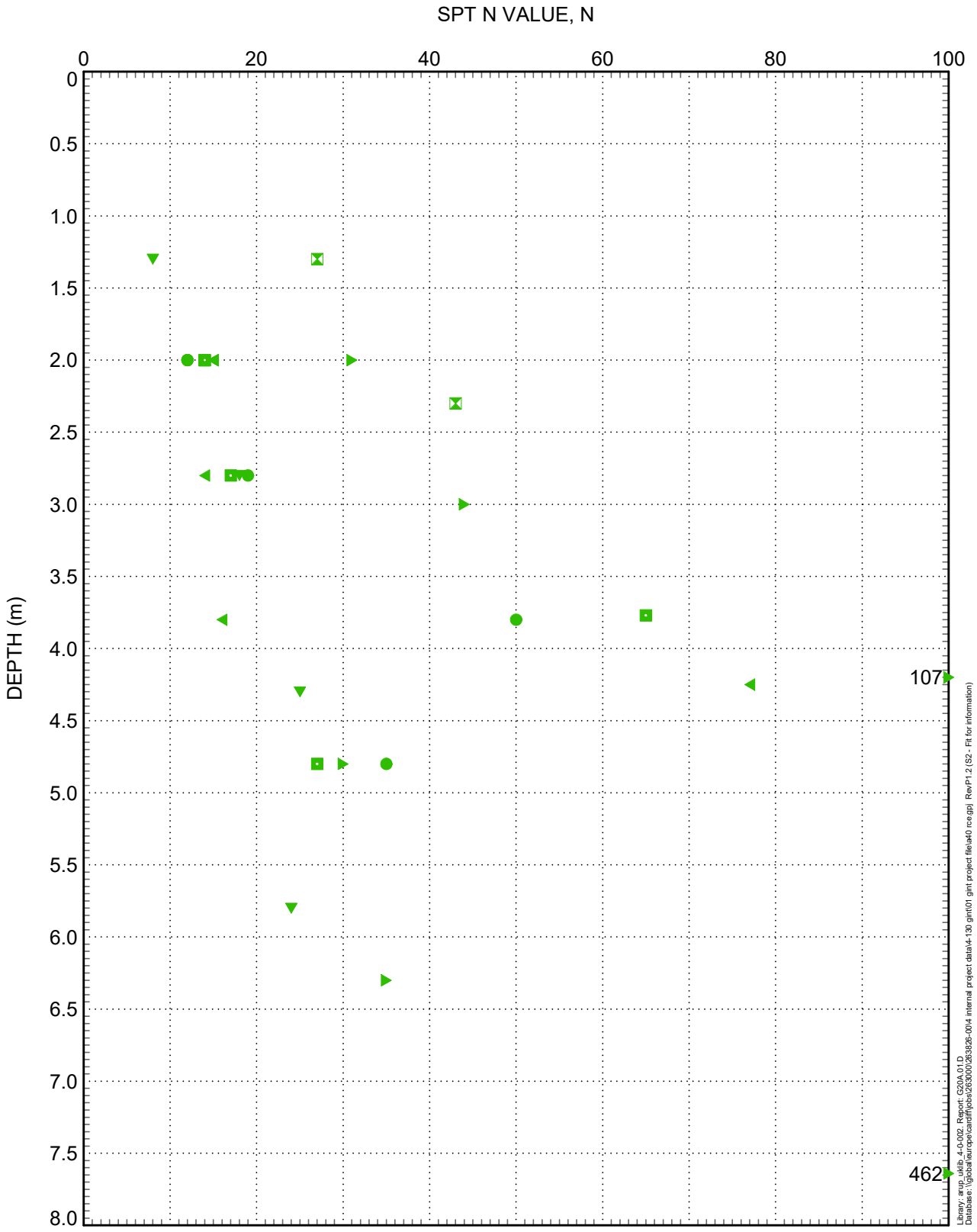
- Glacial Deposits (GTD)
- RCEBH05 CP, 1.65m, 5
- RCEBH05 CP, 2.45m, 8
- RCEBH05 CP, 3.45m, 13
- RCEBH05 CP, 4.50m, 8
- RCEBH05 CP, 5.45m, 20
- RCEBH06, 0.50m, 2
- RCEBH06, 2.00m, 8
- RCEBH07, 2.00m, 8
- RCEBH07, 4.00m, 17
- RCEBH08, 2.20m, 7
- RCEBH08, 3.20m, 11
- RCEBH08, 5.00m
- RCEBH08, 8.00m, 23
- RCEBH09, 2.10m, 8
- RCEDS06a, 0.40m, 1
- RCEDS06a, 0.40m, 1.1
- RCEDS07, 0.50m, 1
- RCEDS08, 0.50m, 1
- RCEDS10, 0.30m, 1
- RCESA12, 0.50m, 2
- RCETP08, 0.50m, 3
- RCETP09, 0.50m, 3
- RCETP09, 1.50m, 5
- RCETP10, 0.50m, 3
- RCETP11, 0.50m, 3
- RCETP12, 0.50m, 3
- RCETP12, 1.10m, 4

A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION
GLACIAL DEPOSITS

263826-00

FIGURE 15

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20



Library: arup_lwlib_4-0-002, Report: C20A.01.D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj ReviP1.2 (S2 - Fit for information)

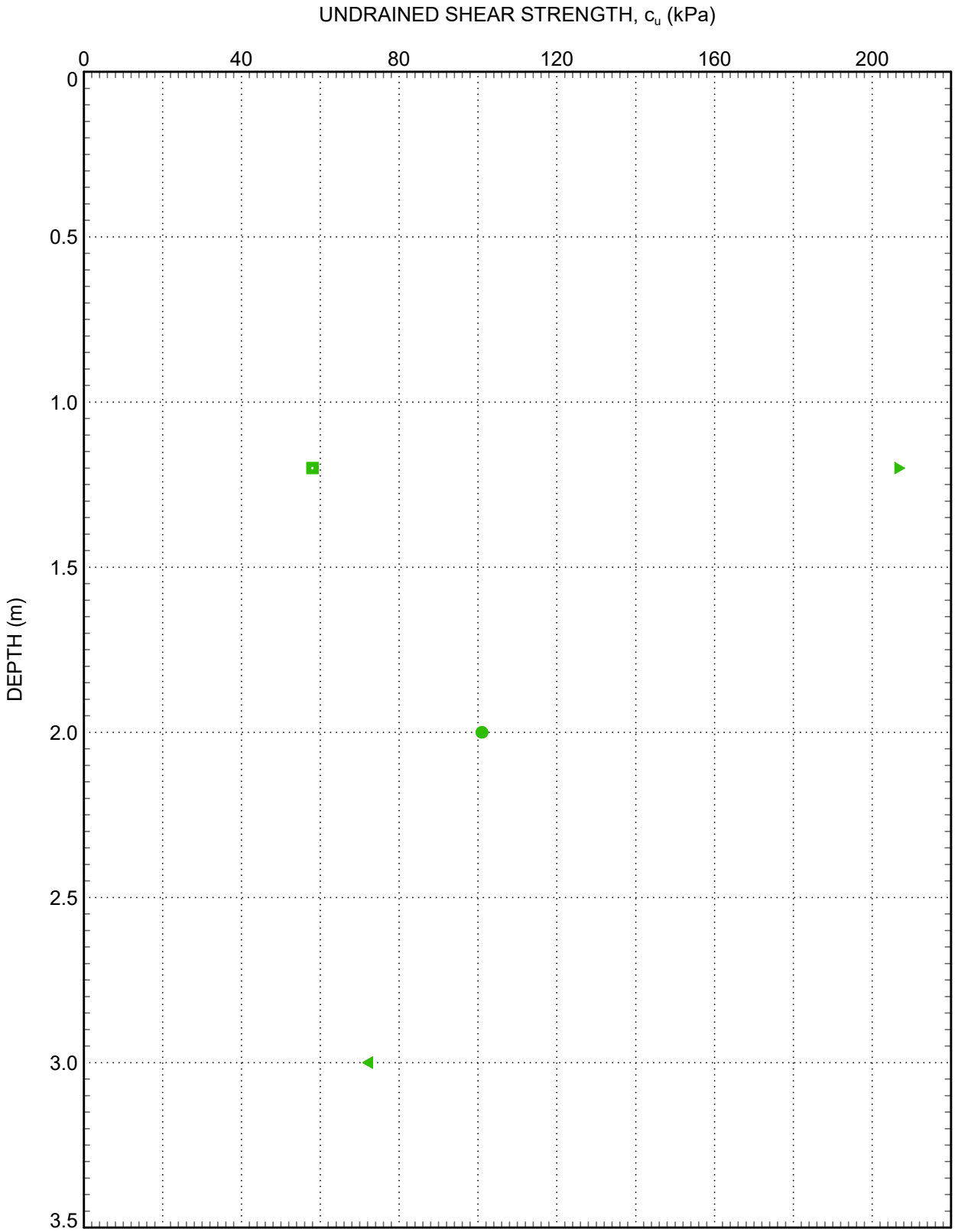
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
STANDARD PENETRATION TESTS
GLACIAL DEPOSITS

263826-00

FIGURE 16



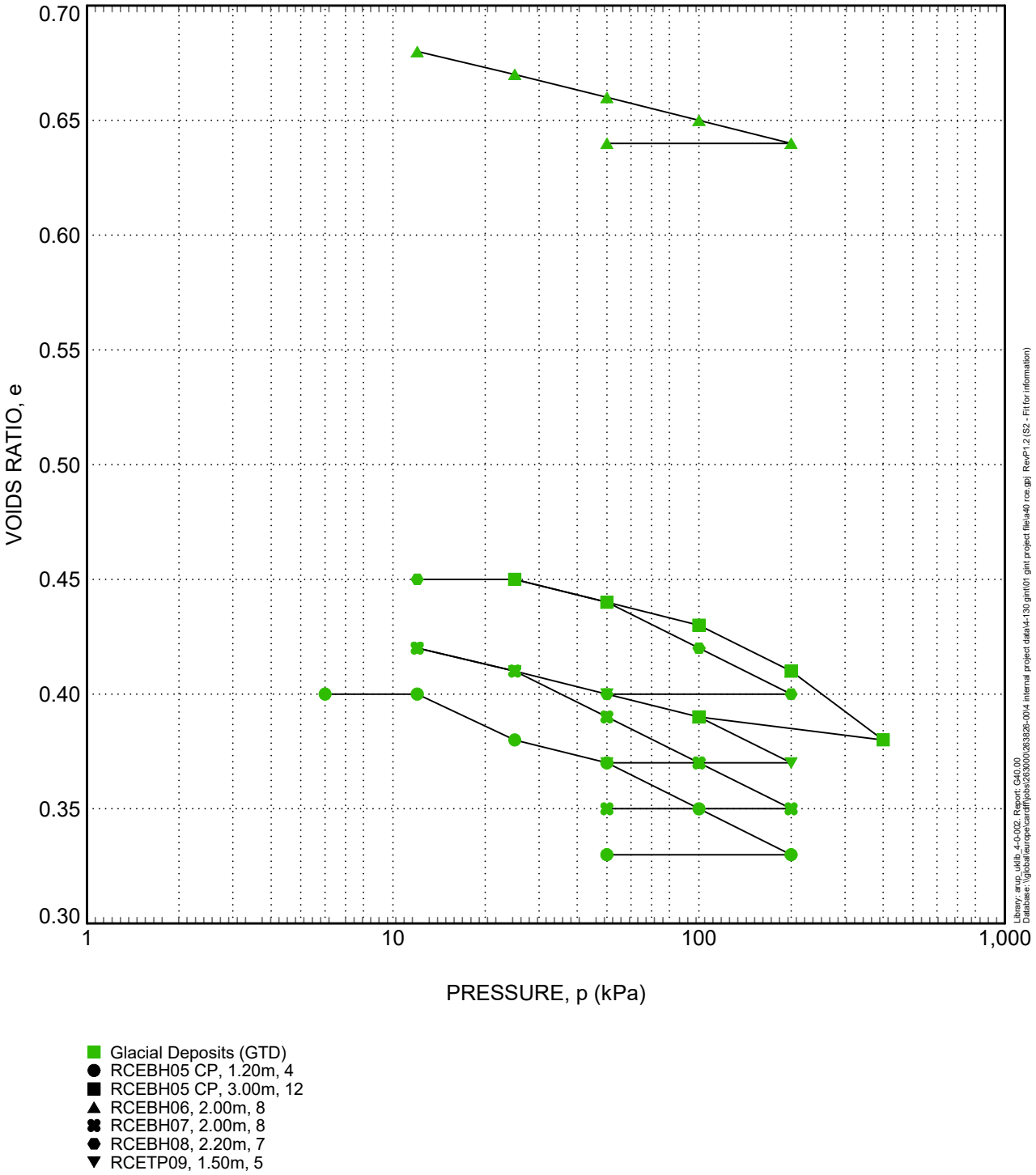
A40 REDSTONE CROSS IMPROVEMENTS
TRIAXIAL UNDRAINED SHEAR STRENGTH
GLACIAL DEPOSITS

263826-00

FIGURE 17

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

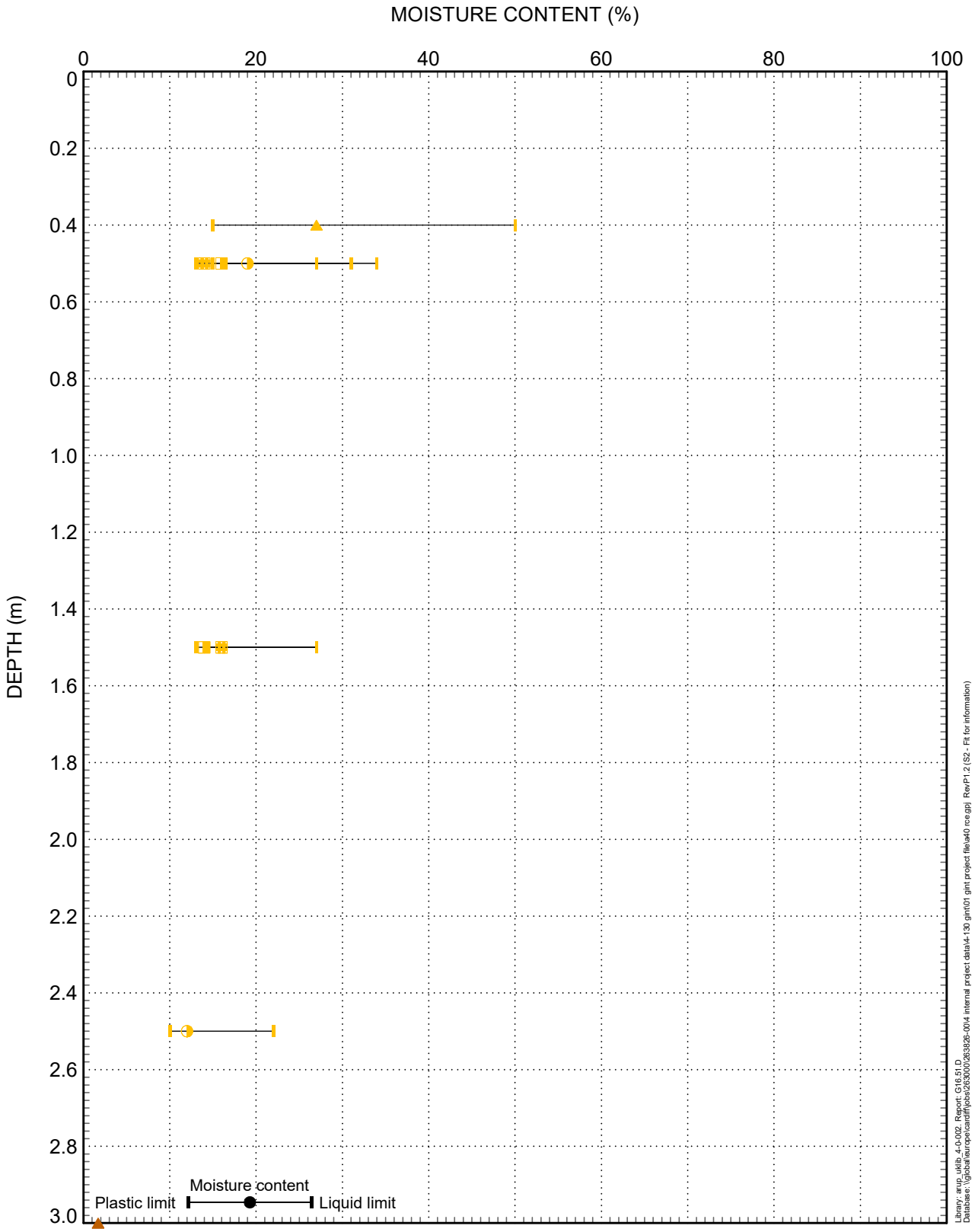


A40 REDSTONE CROSS IMPROVEMENTS
CONSOLIDATION TESTS
GLACIAL DEPOSITS

263826-00

FIGURE 18

ARUP_gINT_v8.30.003
Made by Aodhan Teegue on 24-Feb-20



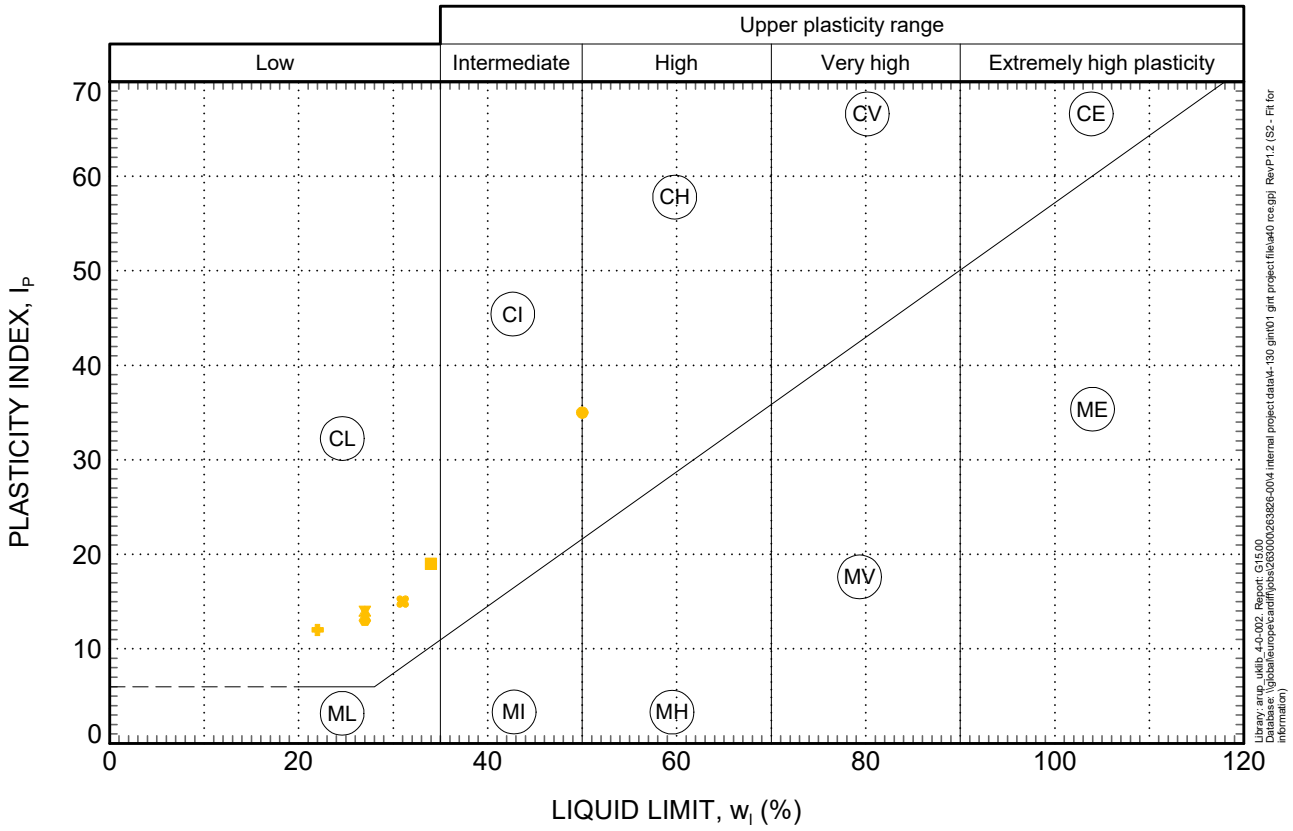
- Weathered Haverford Beds Formation (WHB)
- Haverford Beds Formation (HB)
- RCEBH01
- RCETP01
- RCETP02
- RCETP03

A40 REDSTONE CROSS IMPROVEMENTS
ATTERBERG LIMITS
HAVERFORD BEDS FORMATION & WEATHERED HAVERFORD BEDS FORMATION
263826-00

FIGURE 19

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



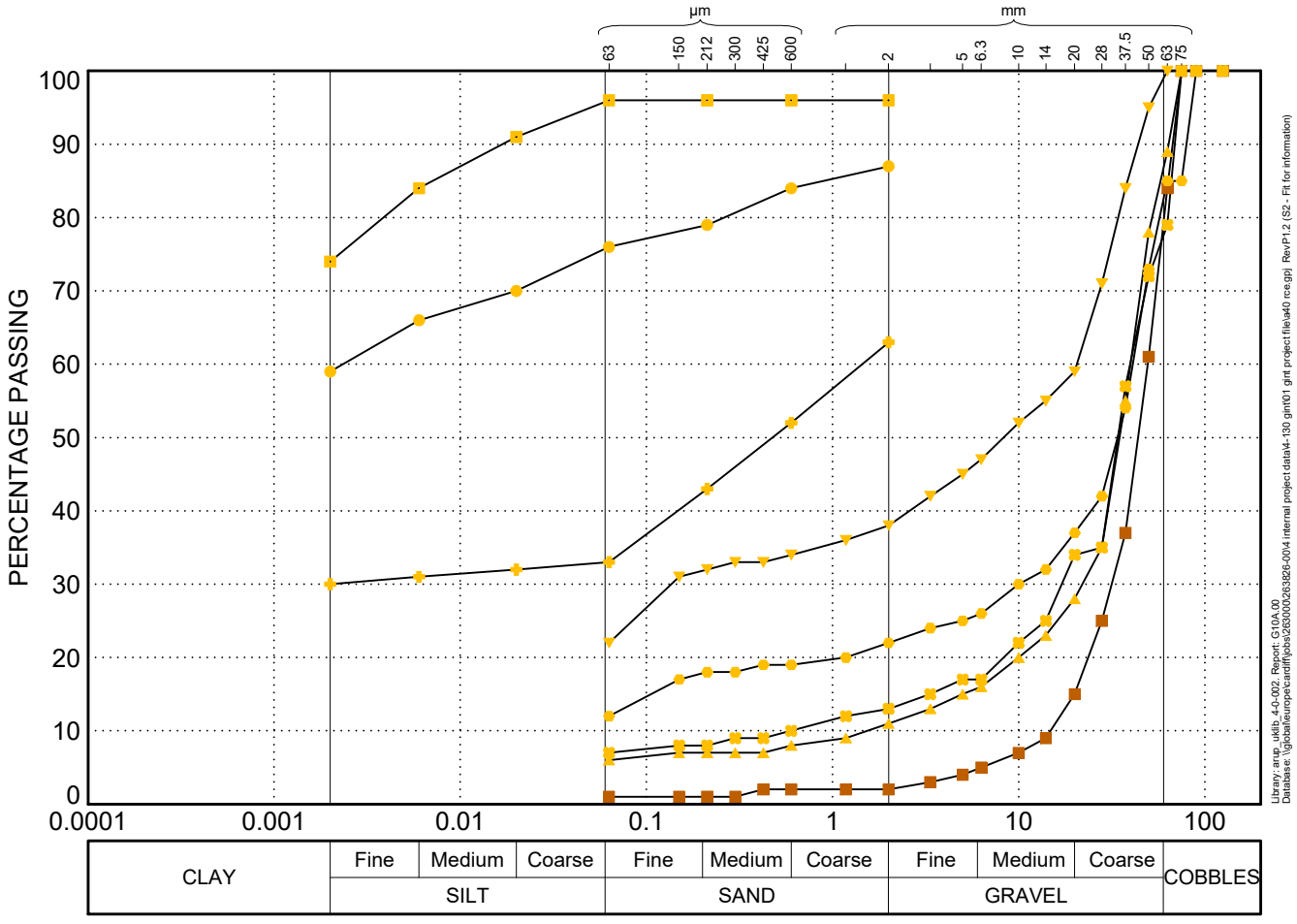
- Weathered Haverford Beds Formation (WHB)
- RCEBH01, 0.40m, 2
- RCETP01, 0.50m, 3
- RCETP01, 1.50m, 5
- RCETP02, 0.50m, 3
- RCETP02, 1.50m, 5
- RCETP03, 0.50m, 3
- RCETP03, 2.50m, 6

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
PLASTICITY CHART
HAVERFORD BEDS FORMATION & WEATHERED HAVERFORD BEDS FORMATION
263826-00

FIGURE 20

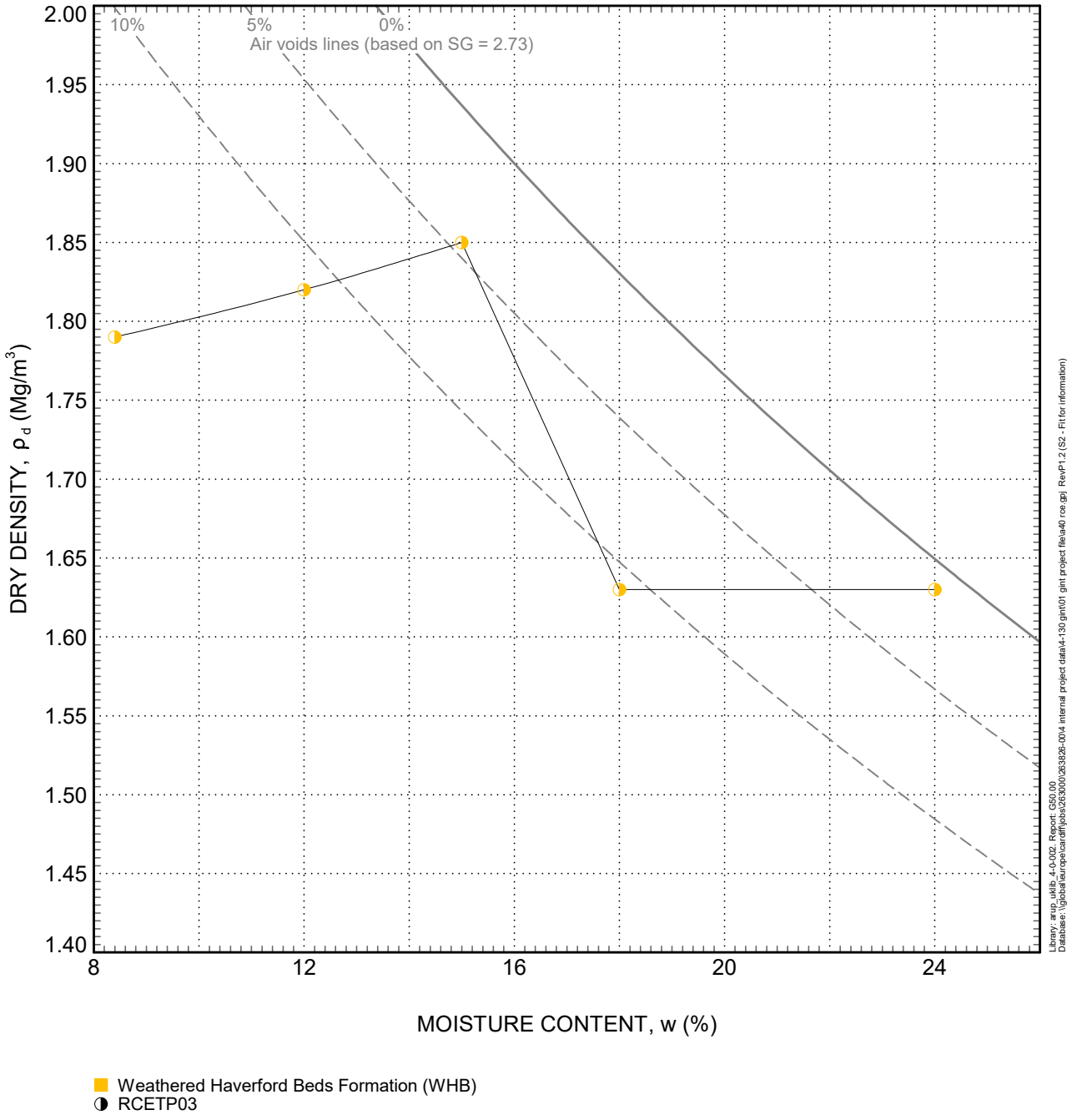


ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION HAVERFORD BEDS FORMATION & WEATHERED HAVERFORD BEDS FORMATION
263826-00

FIGURE 21

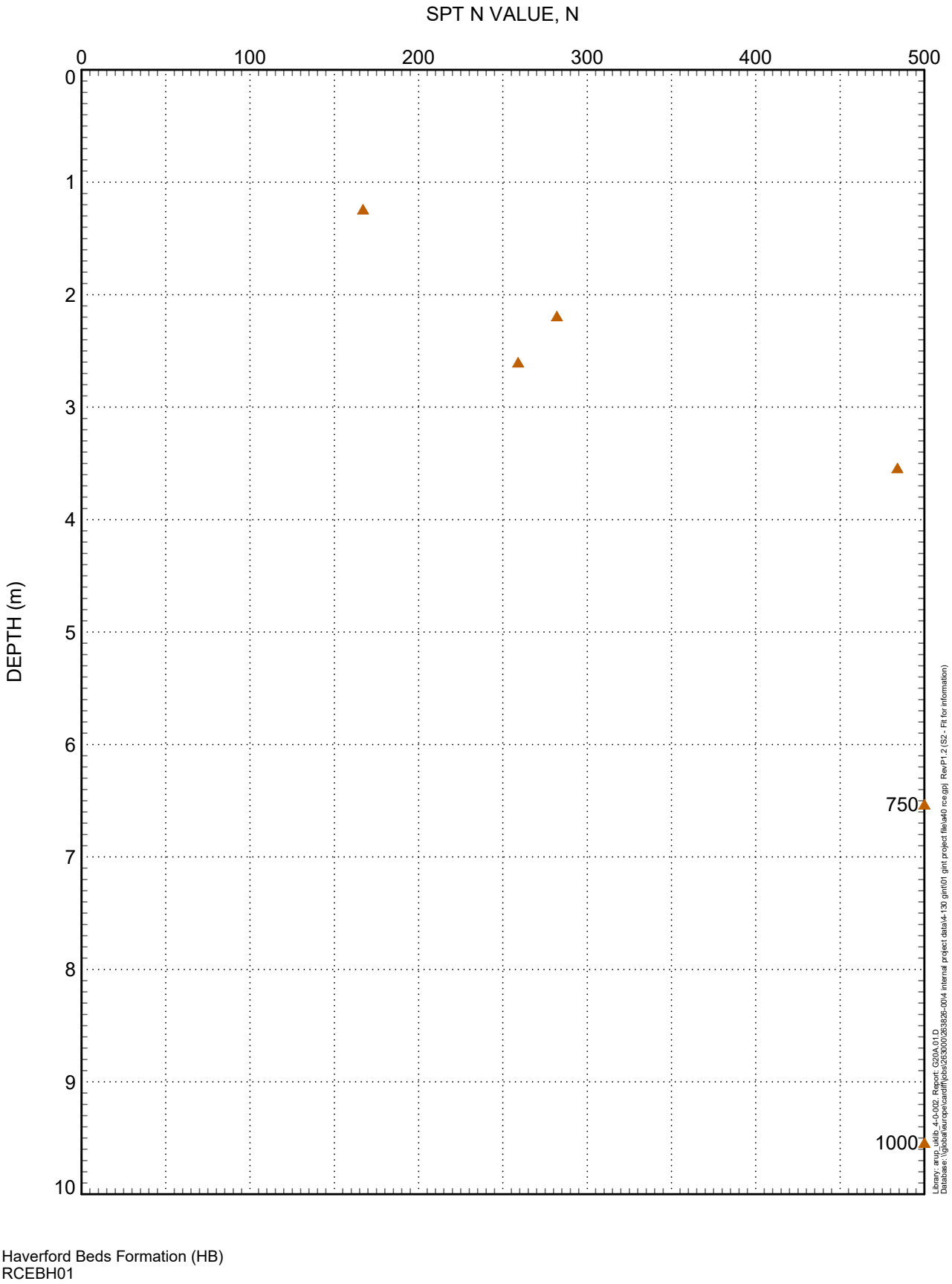


A40 REDSTONE CROSS IMPROVEMENTS
COMPACTION TESTS
WEATHERED HAVERFORD BEDS FORMATION

263826-00

FIGURE 22

ARUP_gINT_v8.30.003
Made by Aodhan Teague on 24-Feb-20



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Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj ReviP1.2 (S2 - Fit for information)

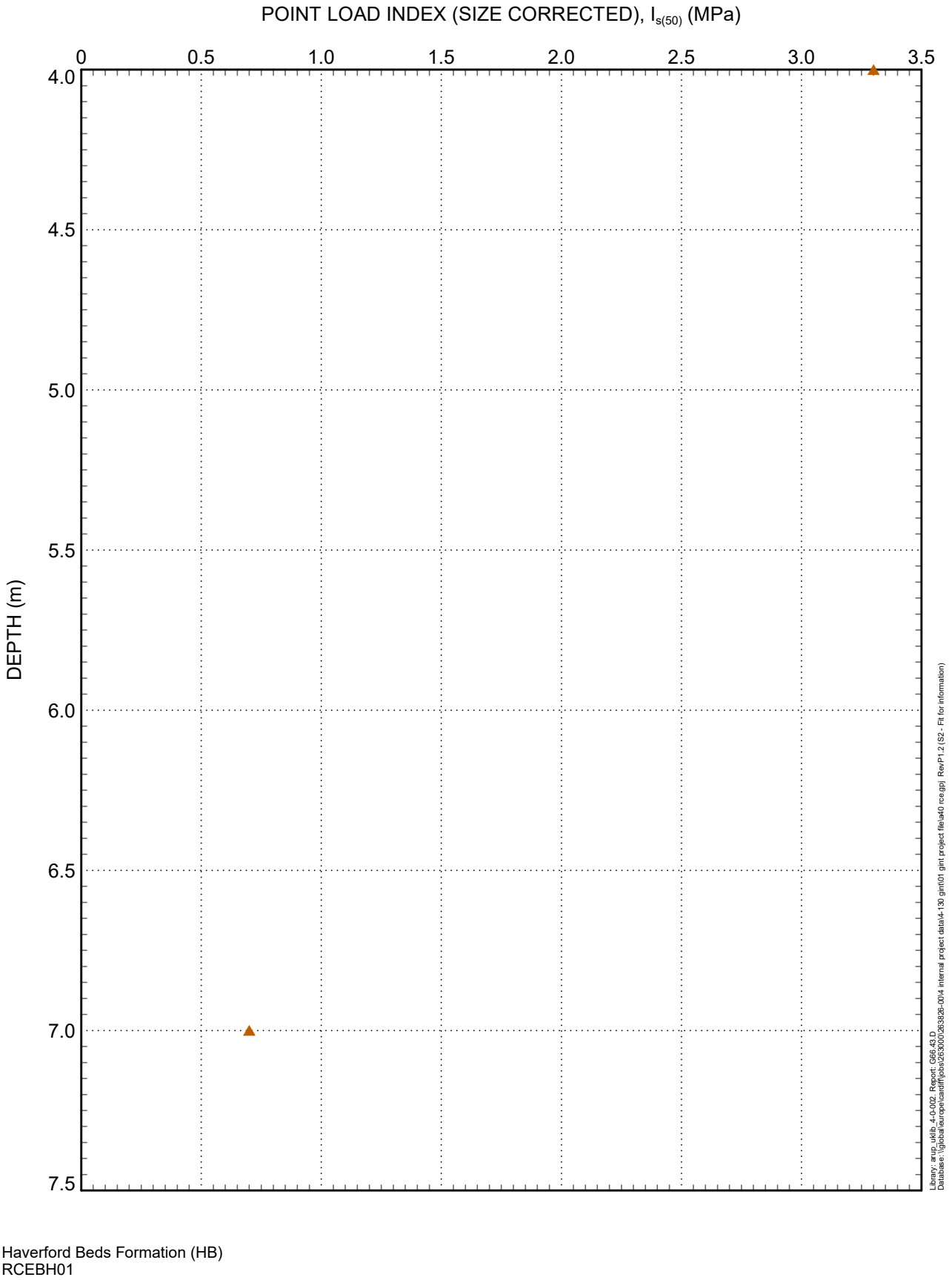
A40 REDSTONE CROSS IMPROVEMENTS
STANDARD PENETRATION TESTS
HAVERFORD BEDS FORMATION

263826-00

FIGURE 23

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



Library: arup_uklib_4-0-002_Report: G66_43_D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

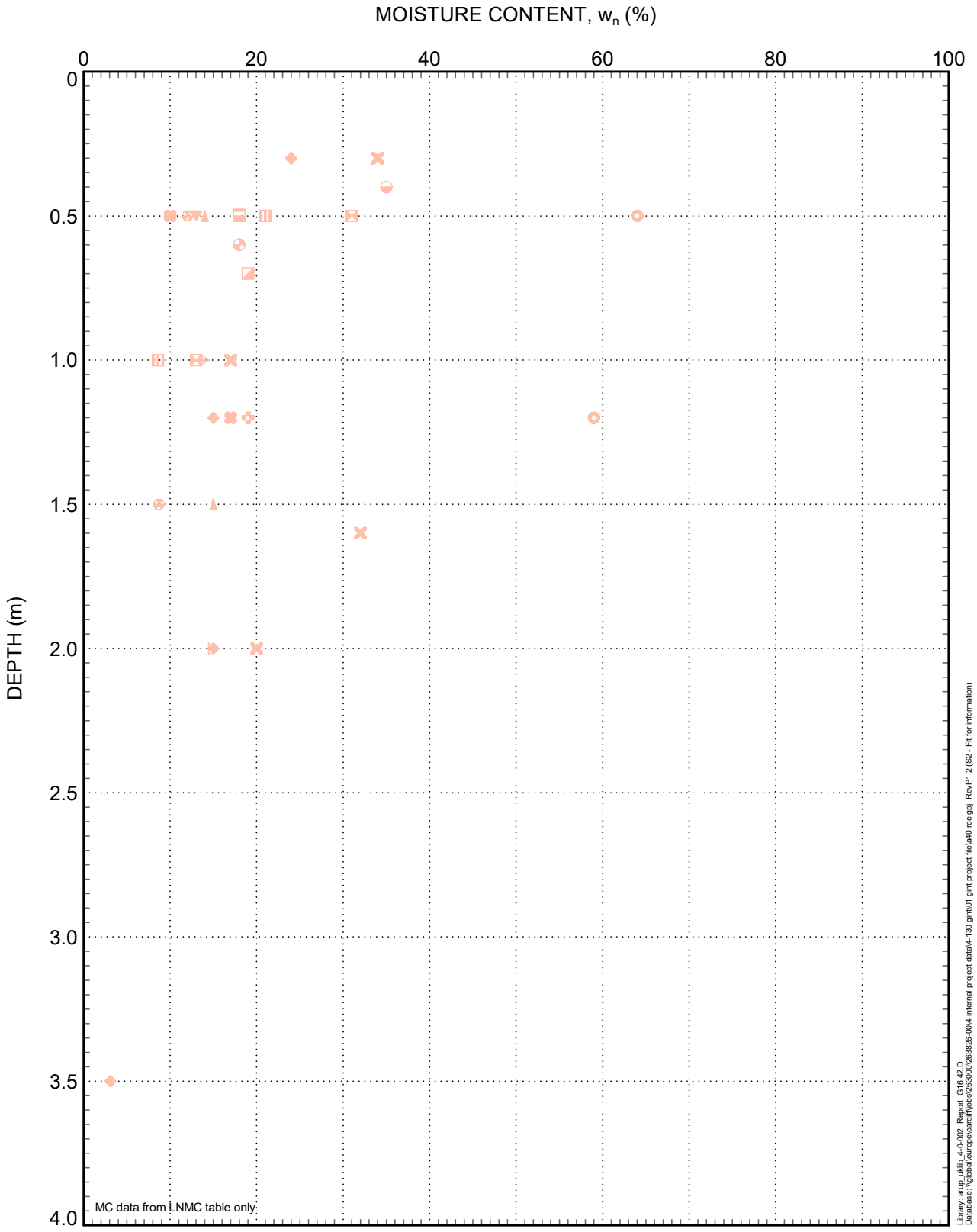
A40 REDSTONE CROSS IMPROVEMENTS
POINT LOAD INDEX (SIZE CORRECTED)
HAVERFORD BEDS FORMATION

263826-00

FIGURE 24

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



Weathered Slade and Redhill Formation (WSR)
RCEBH02
RCEBH04
RCEBH12
RCEBH14
RCEDS01
RCEDS02
RCEDS03
RCEDS05
RCETP04
RCETP05
RCETP06
RCETP07
RCETP13
RCETP14
RCETP15
RCETP18
RCETP19
| None | None

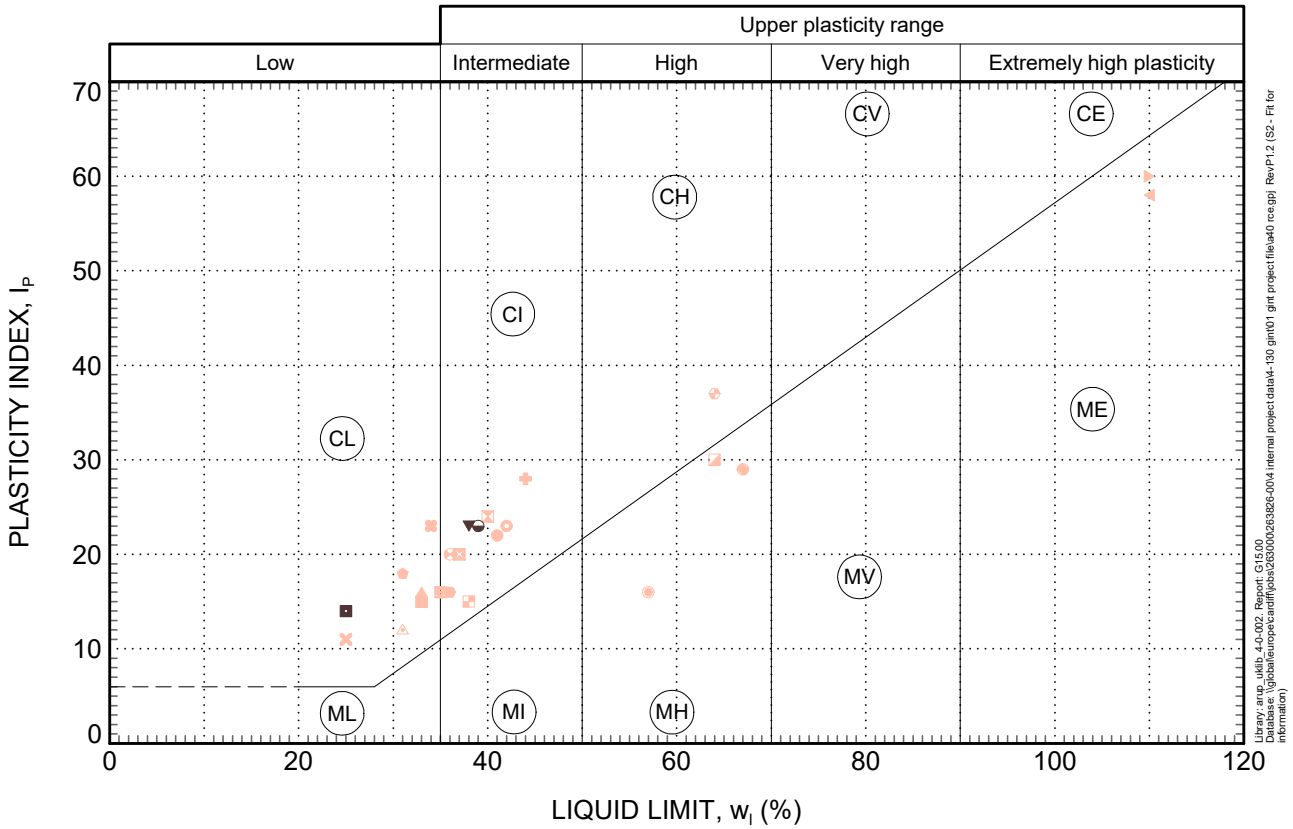
Library: arup_uklib_4-0-002_Report: G16_42_D
Database: \\globaleurope\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project file\a40 rce.gpj RevP1.2 (S2 - Fit for information)

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS
NATURAL MOISTURE CONTENT
WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 25



- Weathered Slade and Redhill Formation (WSR)
- Slade and Redhill Formation (SR)
- RCEBH02, 0.50m, 2
- RCEBH02, 1.20m, 5
- RCEBH04, 0.50m, 2
- RCEBH12, 1.20m, 5
- RCEBH12, 2.00m, 8
- RCEBH13, 1.00m, 3
- RCEBH14, 1.20m, 5
- RCEBH15, 0.50m, 2
- RCEDS01, 0.50m, 1
- RCEDS01, 1.20m, 2
- RCEDS02, 0.70m, 1
- RCEDS03, 0.40m, 1
- RCEDS05, 0.30m, 3
- RCEDS05, 0.30m, 4
- RCEDS05, 1.00m, 3
- RCEDS05, 1.00m, 6
- RCEDS05, 1.60m, 4
- RCEDS05, 2.00m, 5
- RCETP04, 0.30m, 3
- RCETP05, 0.50m, 3
- RCETP06, 2.50m, 6
- RCETP07, 1.00m, 5
- RCETP07, 2.00m, 6
- RCETP13, 0.50m, 4
- RCETP14, 0.50m, 3
- RCETP19, 0.60m, 4

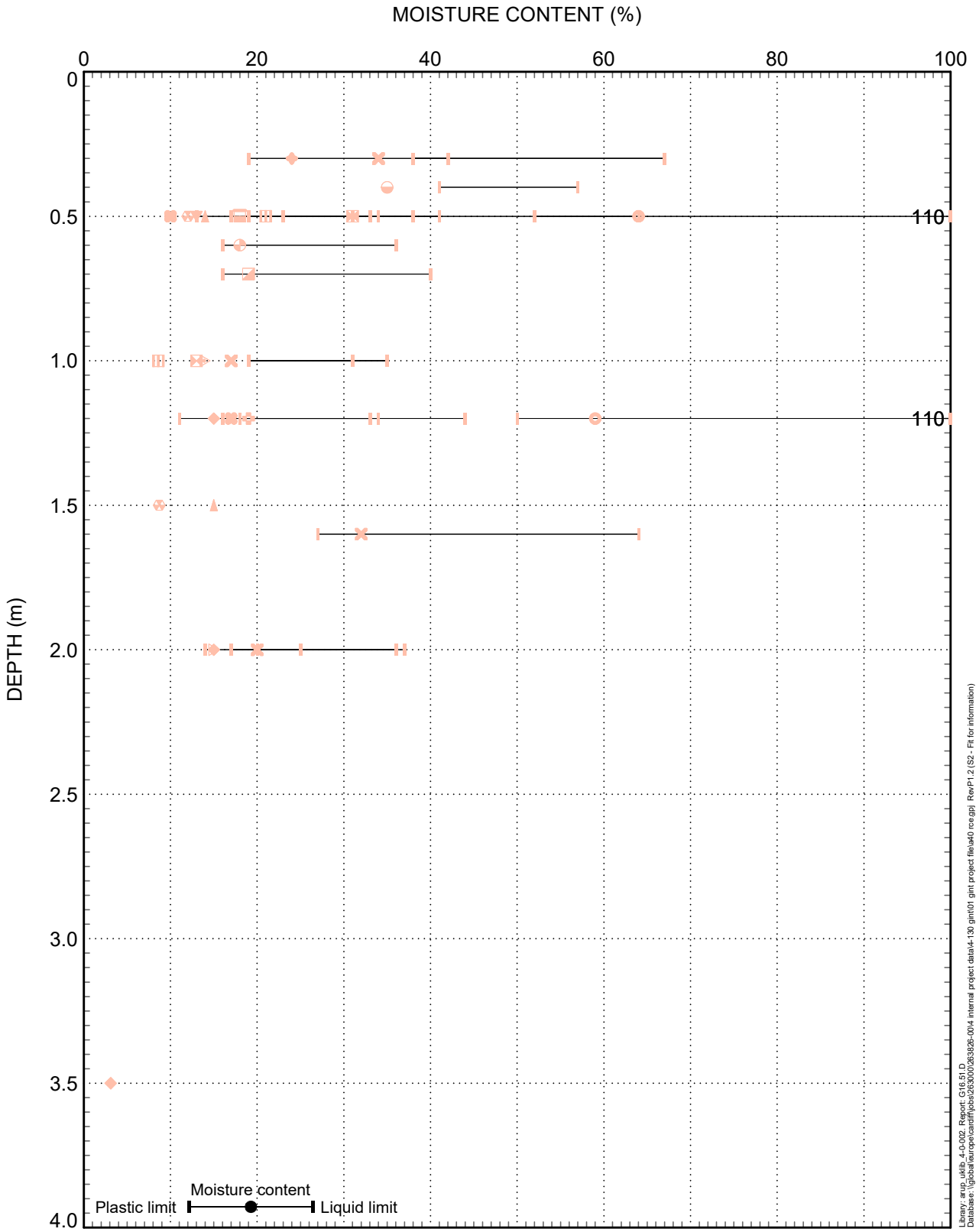
A40 REDSTONE CROSS IMPROVEMENTS
PLASTICITY CHART
SLADE AND REDHILL FORMATION & WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 26

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



Weathered Slade and Redhill Formation (WSR)
RCEBH02
RCEBH04
RCEBH12
RCEBH14
RCEDS01
RCEDS02
RCEDS03
RCEDS05
RCETP04
RCETP05
RCETP06
RCETP07
RCETP13
RCETP14
RCETP15
RCETP18
RCETP19
| None | None

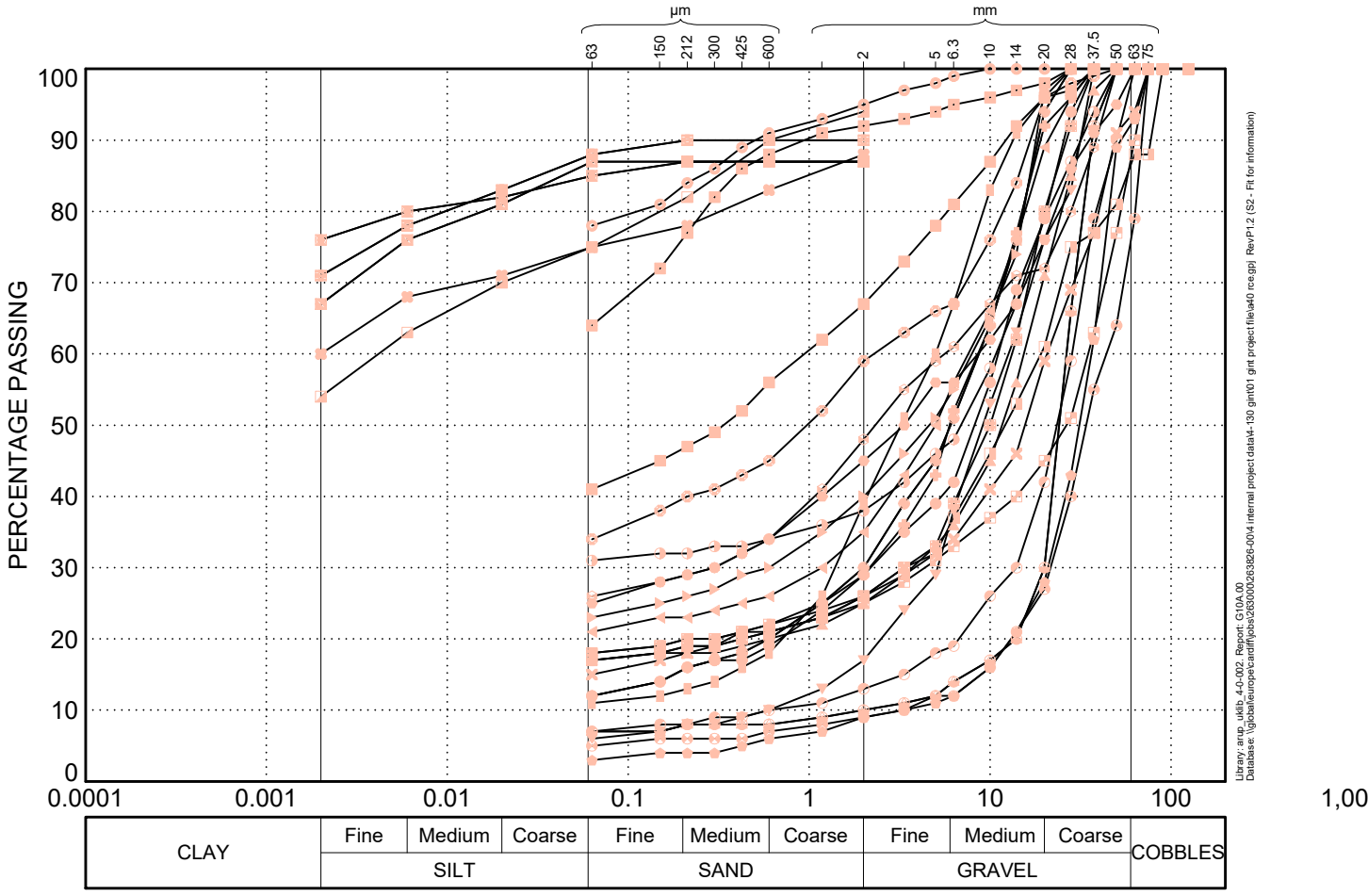
Library: arup_ukllb_4-0-002_Report: G16.51.D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project file\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS
ATTERBERG LIMITS
WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 27



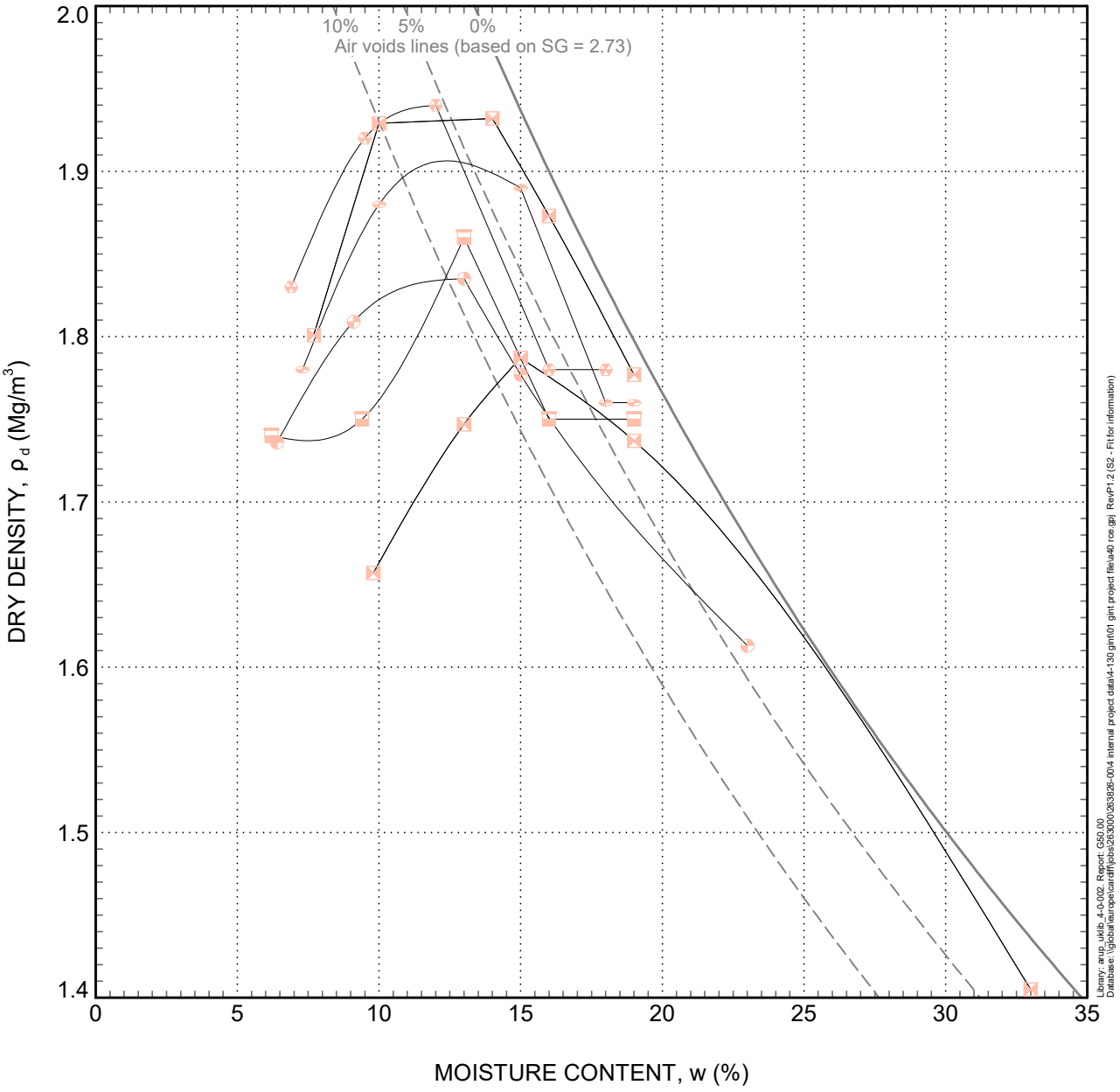
- Weathered Slade and Redhill Formation (WSR)
- RCEBH02, 0.50m, 2
- RCEBH02, 1.20m, 5
- RCEBH04, 0.50m, 2
- RCEBH12, 1.20m, 5
- RCEBH12, 2.00m, 8
- RCEBH12, 3.50m
- RCEDS01, 0.50m, 1
- RCEDS01, 1.20m, 2
- RCEDS02, 0.70m, 1
- RCEDS03, 0.40m, 1
- RCEDS05, 0.30m, 2.1
- RCEDS05, 0.30m, 3
- RCEDS05, 1.00m, 3
- RCEDS05, 1.00m, 6
- RCEDS05, 1.60m, 4.1
- RCEDS05, 1.60m, 8
- RCEDS05, 2.00m, 5.1
- RCEDS05, 2.00m, 9
- RCETP04, 0.30m, 3
- RCETP05, 0.50m, 3
- RCETP05, 1.00m, 5
- RCETP05, 1.00m, 5.1
- RCETP06, 0.50m, 4
- RCETP06, 1.50m, 5
- RCETP07, 1.00m, 5
- RCETP07, 2.00m, 6
- RCETP13, 0.50m, 4
- RCETP13, 1.50m, 5
- RCETP14, 0.50m, 3
- RCETP14, 1.00m, 4
- RCETP15, 0.50m, 4
- RCETP18, 0.50m, 3
- RCETP19, 0.60m, 4

A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION
WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 28

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

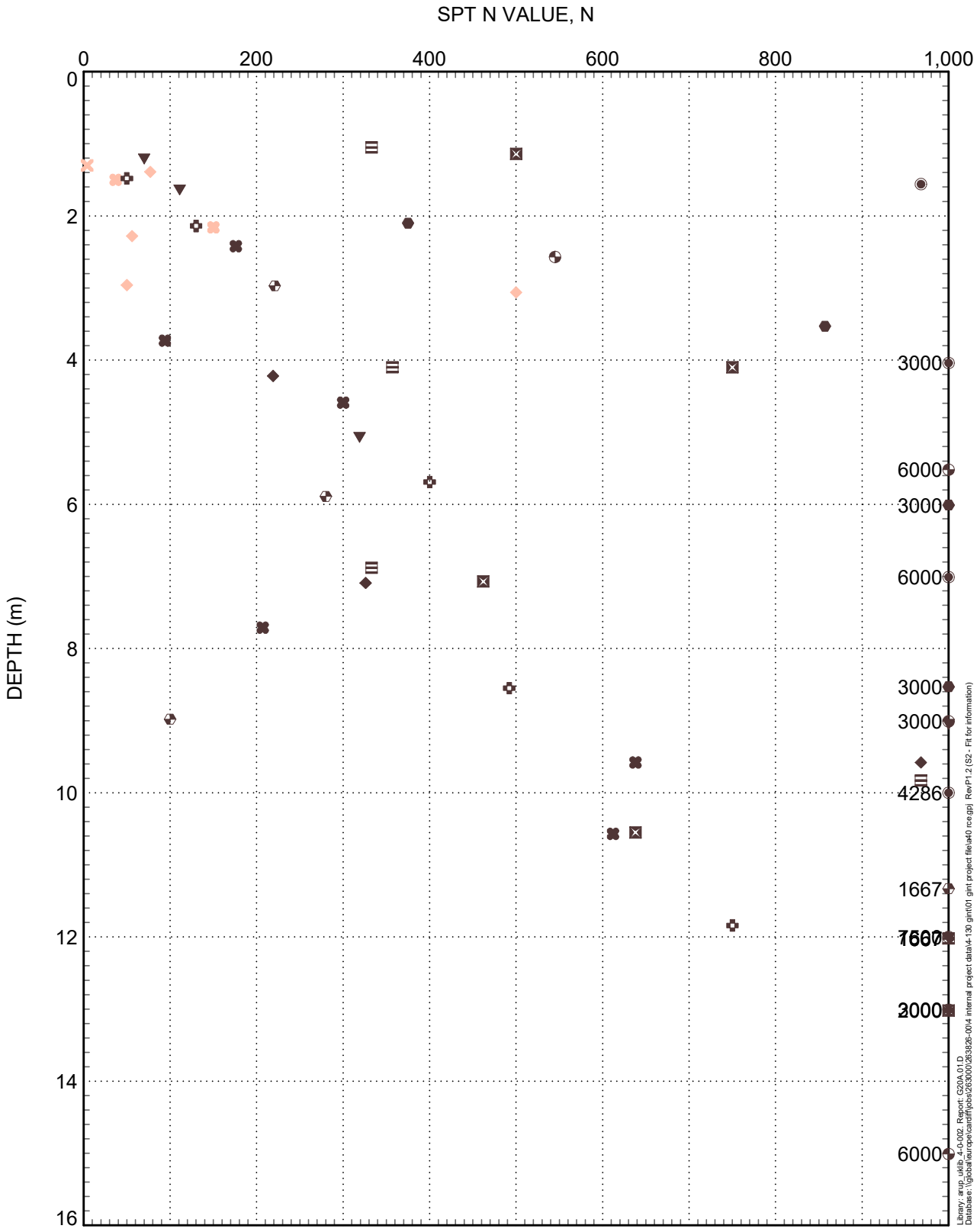


A40 REDSTONE CROSS IMPROVEMENTS
COMPACTION TESTS
WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 29

ARUP_gINT_v8.30.003
Made by Aodhan Teague on 24-Feb-20



- Weathered Slade and Redhill Formation (WSR)
- Slade and Redhill Formation (SR)
- RCEBH02
- RCEBH03
- RCEBH04
- RCEBH10
- RCEBH11
- RCEBH12
- RCEBH13
- RCEBH14
- RCEBH15
- RCEBH16
- RCEDS05

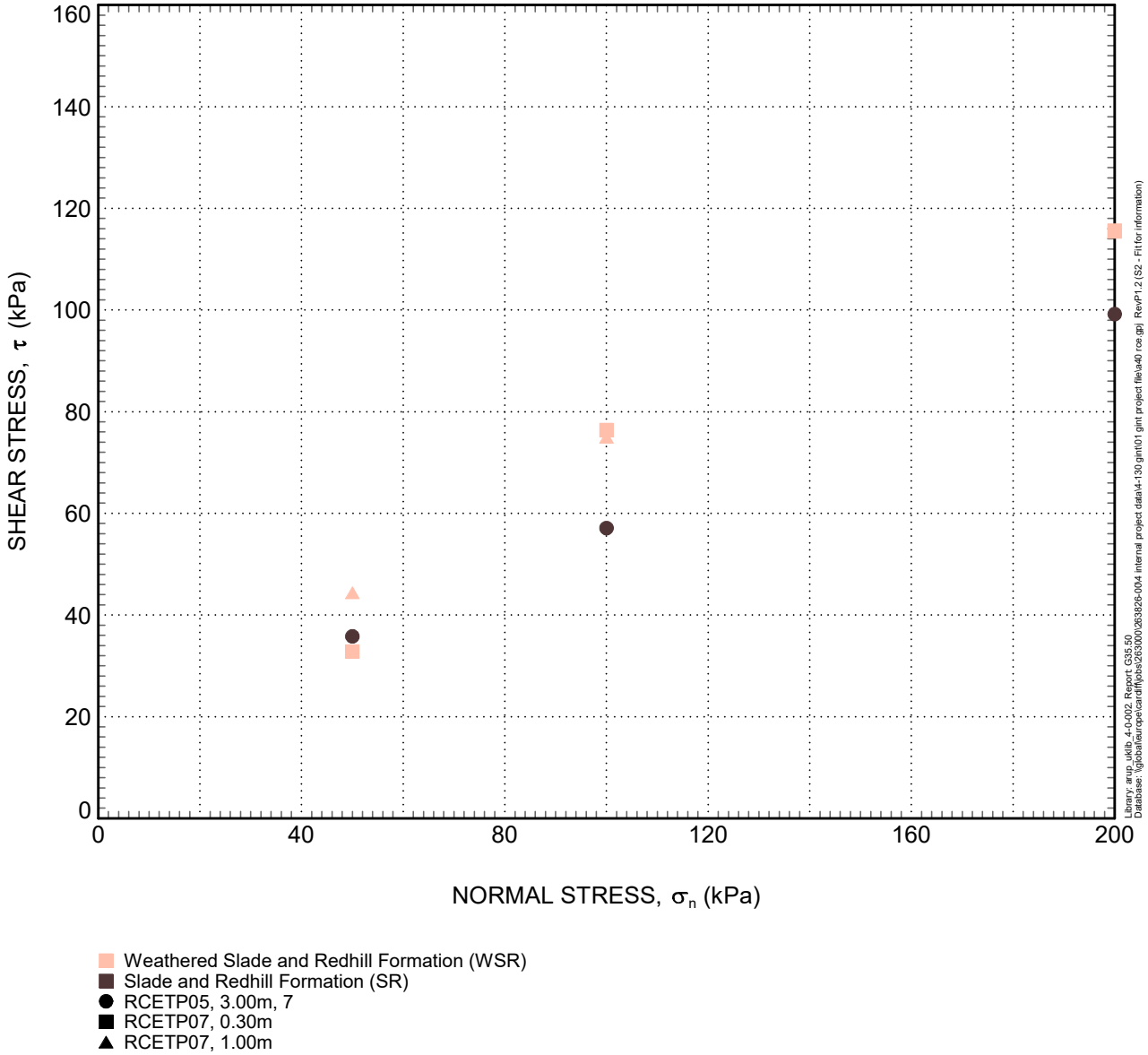
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
STANDARD PENETRATION TESTS SLADE AND REDHILL FORMATION & WEATHERED SLADE AND REDHILL FORMATION

263826-00

FIGURE 30

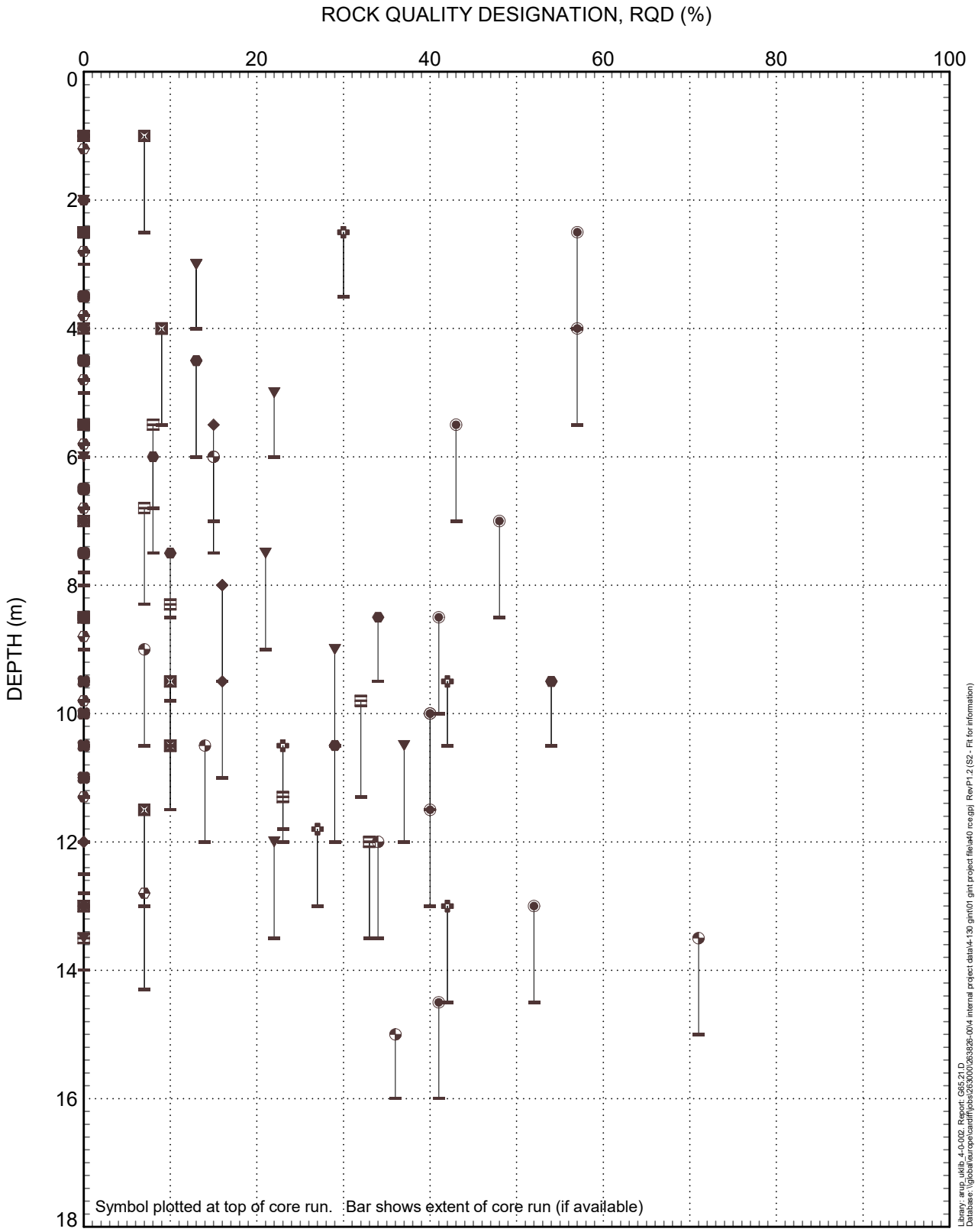


A40 REDSTONE CROSS IMPROVEMENTS
SHEAR BOX TESTS
SLADE AND REDHILL FORMATION & WEATHERED SLADE AND REDHILL FORMATION
263826-00

FIGURE 31

ARUP, gINT v6.32.003
Made by Aodhan Teague on 24-Feb-20

| None | None



- Slade and Redhill Formation (SR)
- RCEBH02
- RCEBH03
- RCEBH04
- RCEBH10
- RCEBH11
- RCEBH12
- RCEBH13
- RCEBH14
- RCEBH15
- RCEBH16

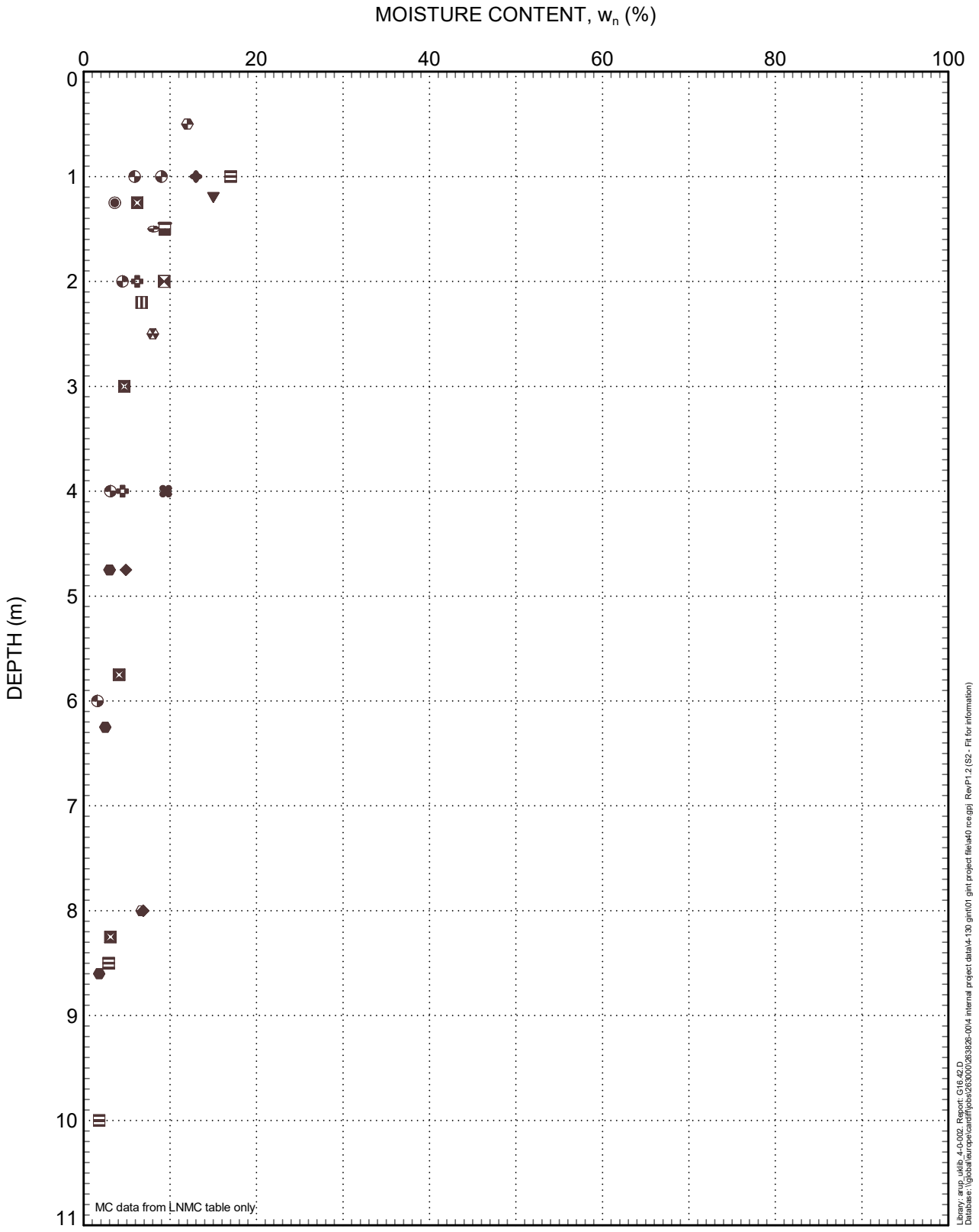
A40 REDSTONE CROSS IMPROVEMENTS
ROCK QUALITY DESIGNATION
SLADE AND REDHILL FORMATION

263826-00

FIGURE 32

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



- Slade and Redhill Formation (SR)
- RCEBH02
- RCEBH03
- RCEBH04
- RCEBH10
- RCEBH11
- RCEBH12
- RCEBH13
- RCEBH14
- RCEBH15
- RCEBH16
- RCETP04
- RCETP05
- RCETP06
- RCETP14
- RCETP15
- RCETP18
- RCETP19

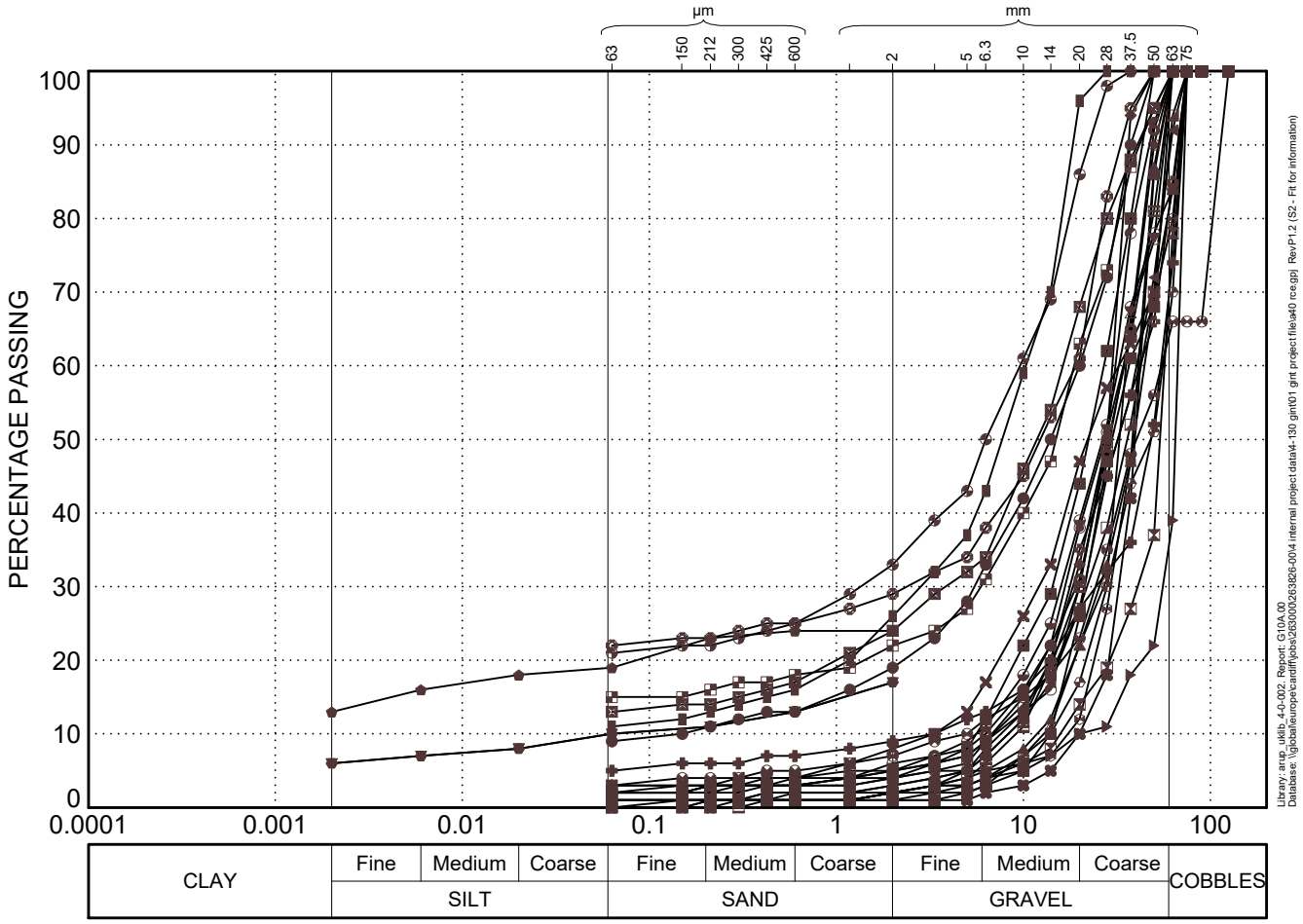
| None | None

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

A40 REDSTONE CROSS IMPROVEMENTS
NATURAL MOISTURE CONTENT
SLADE AND REDHILL FORMATION

263826-00

FIGURE 33



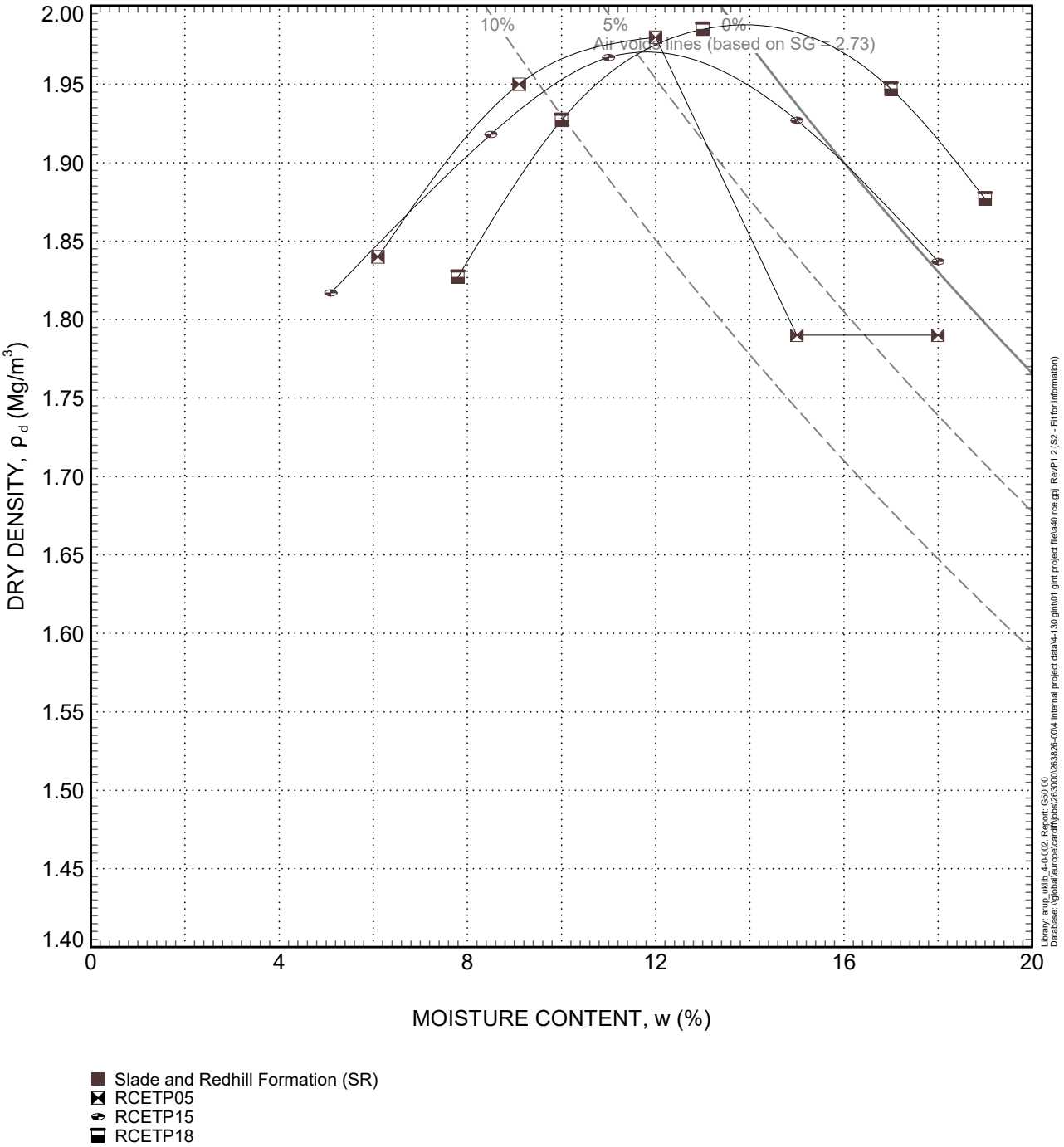
- Slade and Redhill Formation (SR)
- RCEBH02, 4.00m
- RCEBH03, 4.75m, 5
- RCEBH03, 6.25m, 7
- RCEBH03, 8.60m, 8
- RCEBH04, 1.20m, 4
- RCEBH04, 1.20m, 5
- RCEBH10, 1.25m, 1
- RCEBH11, 1.00m
- RCEBH11, 4.00m
- RCEBH11, 6.00m
- RCEBH12, 4.75m
- RCEBH12, 8.00m
- RCEBH13, 1.00m, 3
- RCEBH13, 8.50m
- RCEBH13, 10.00m
- RCEBH14, 2.00m, 4
- RCEBH14, 4.00m, 7
- RCEBH15, 0.50m, 2
- RCEBH15, 8.00m
- RCEBH16, 1.25m, 1
- RCEBH16, 3.00m, 4
- RCEBH16, 5.75m, 6
- RCEBH16, 8.25m, 8
- RCETP04, 1.00m, 4
- RCETP05, 2.00m, 6
- RCETP06, 2.50m, 6
- RCETP14, 2.20m, 6
- RCETP15, 1.20m, 5
- RCETP18, 1.50m, 5
- RCETP19, 1.00m, 5

A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION
SLADE AND REDHILL FORMATION

263826-00

FIGURE 34

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20



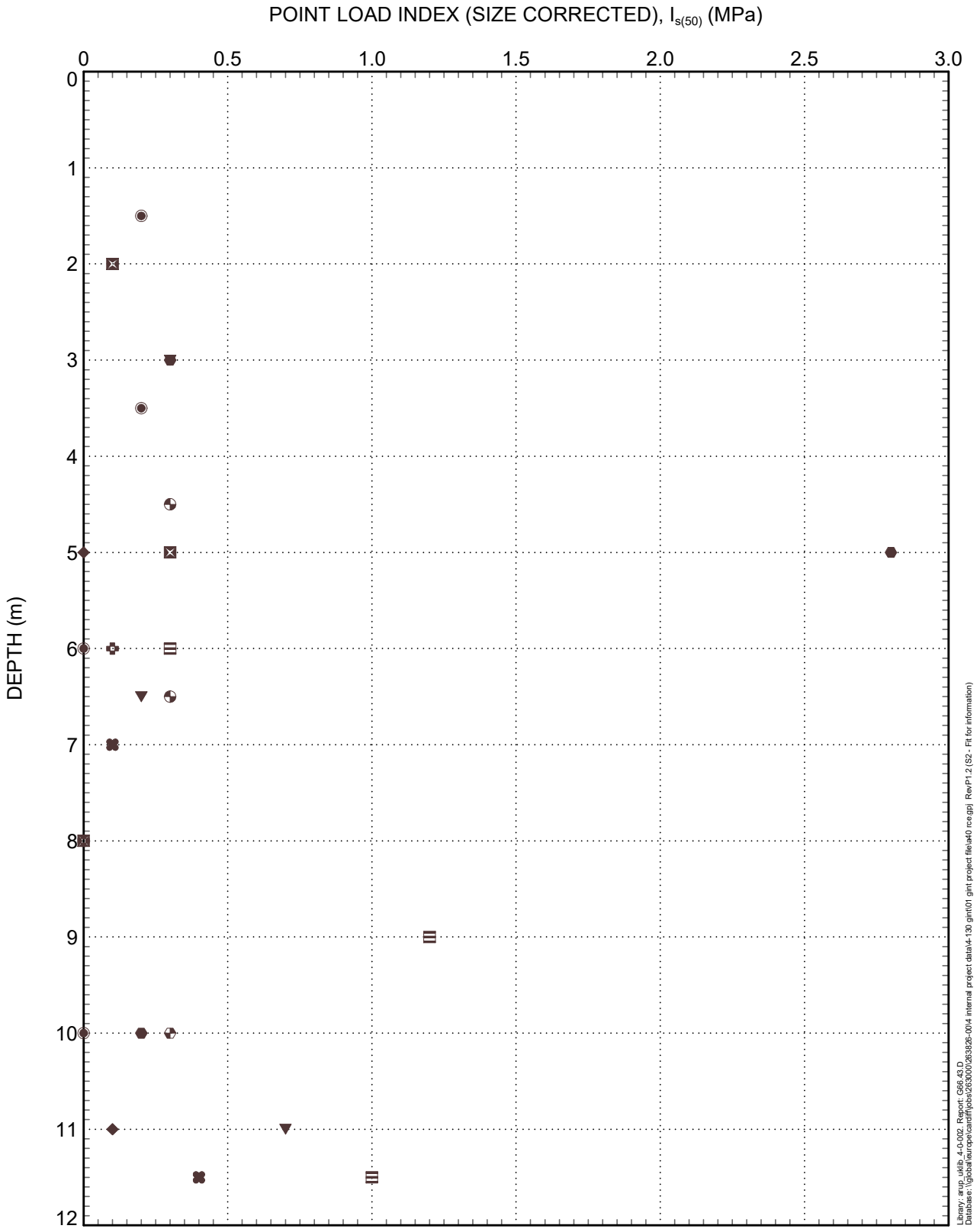
A40 REDSTONE CROSS IMPROVEMENTS
COMPACTION TESTS
SLADE AND REDHILL FORMATION

263826-00

FIGURE 35

ARUP_gINT_v8.30.003
Made by Aodhan Teigue on 24-Feb-20

| None | None



Library: arup_uklib_4-0-002, Report: G66_43_D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

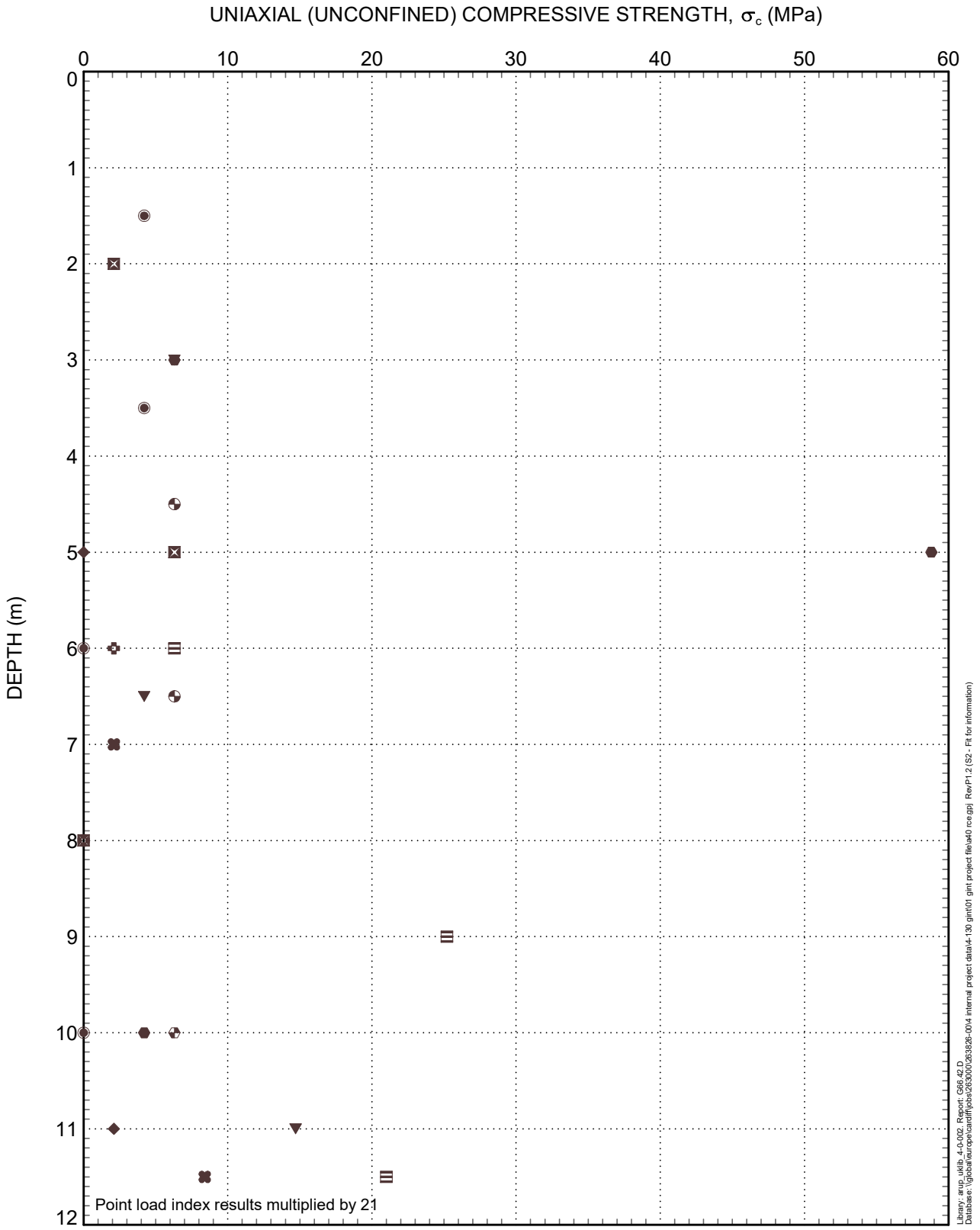
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
POINT LOAD INDEX (SIZE CORRECTED)
SLADE AND REDHILL FORMATION

263826-00

FIGURE 36



Slade and Redhill Formation (SR)
RCEBH02
RCEBH03
RCEBH04
RCEBH10
RCEBH11
RCEBH12
RCEBH13
RCEBH14
RCEBH15
RCEBH16

Library: arup_uklib_4-0-002, Report: G66_42_D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

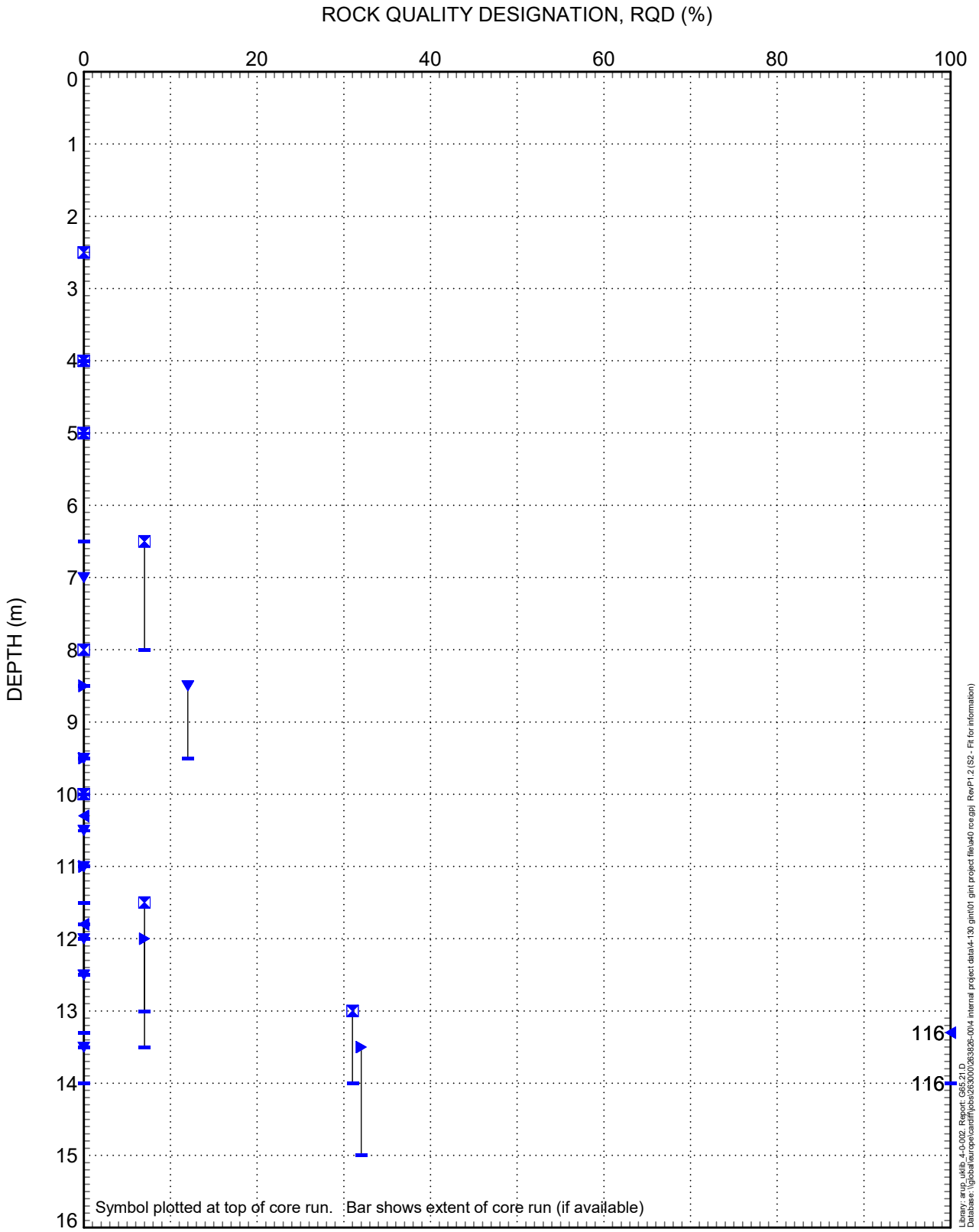
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
UCS FROM POINT LOAD TESTS
SLADE AND REDHILL FORMATION

263826-00

FIGURE 37



- Dicranograptus Beds Formation (DB)
- RCEBH05 ROT
- RCEBH07
- RCEBH08
- RCEBH09

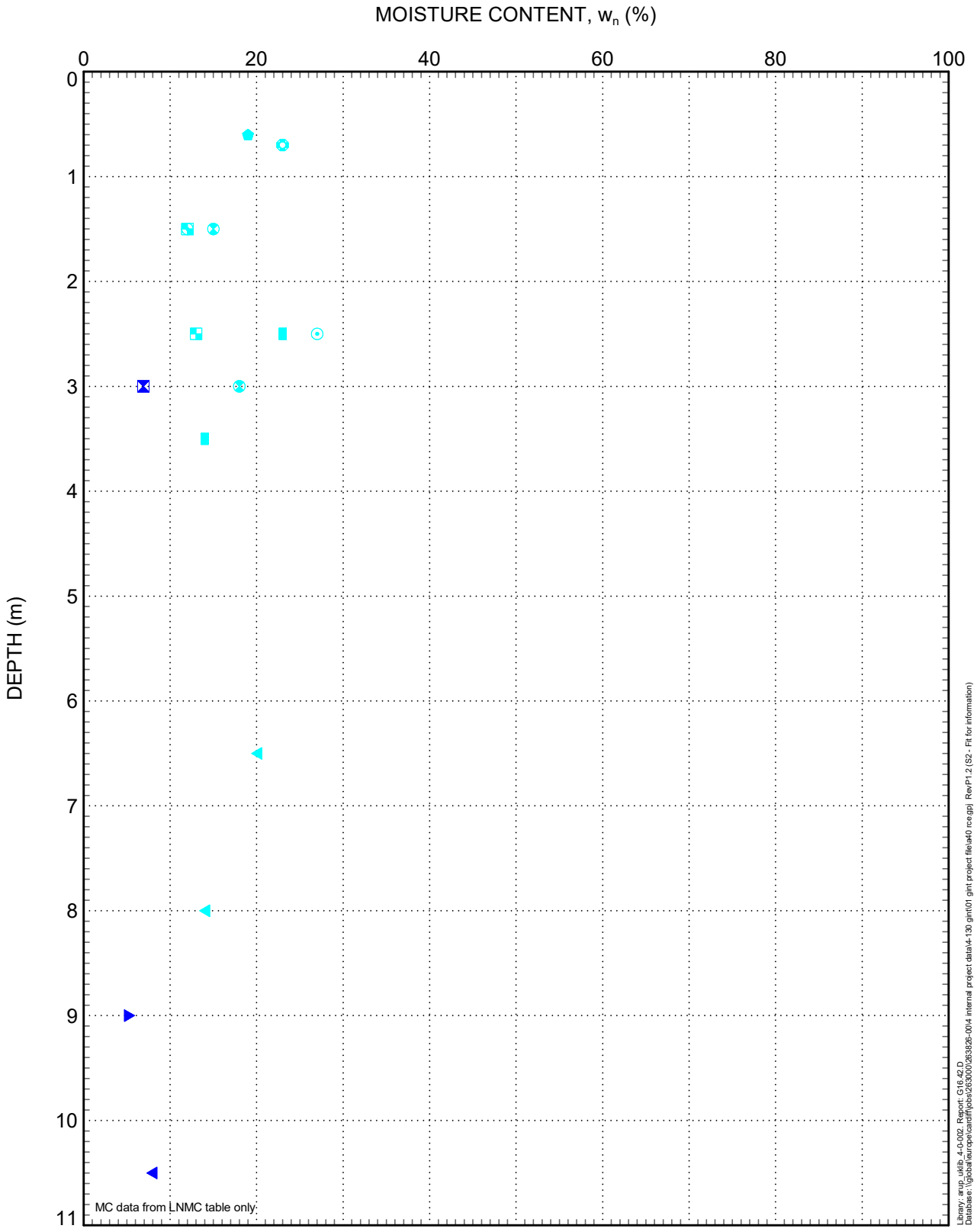
A40 REDSTONE CROSS IMPROVEMENTS
ROCK QUALITY DESIGNATION INTACT DICRANOGRAPTUS BEDS FORMATION

263826-00

FIGURE 38

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



Weathered Dicranograptus Beds Formation (WDB)
Dicranograptus Beds Formation (DB)
RCEBH07
RCEBH08
RCEBH09
RCEDS06a
RCEDS10
RCETP08
RCETP10
RCETP11
RCETP12

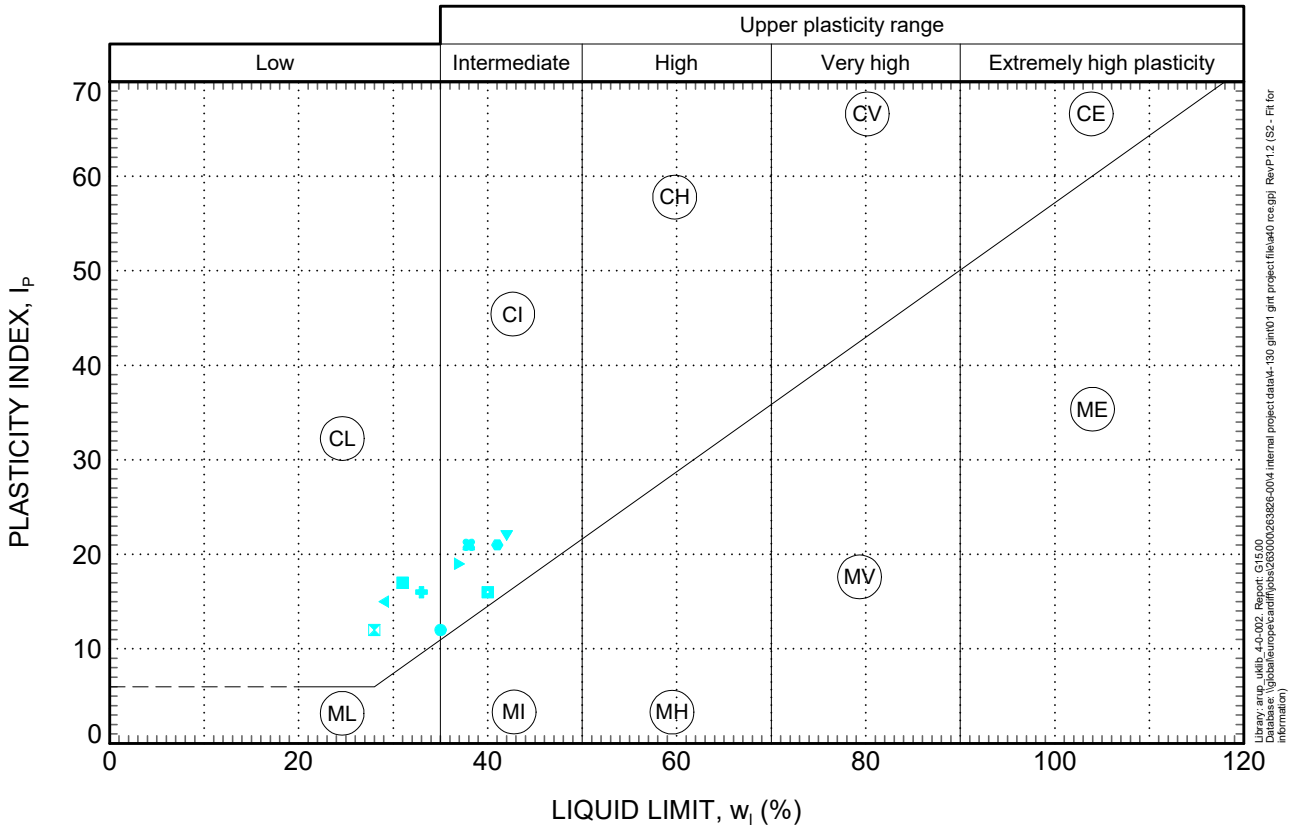
Library: arup_uklib_4-0-002, Report: G16_42_D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj, ReviP1.2 (S2 - Fit for information)

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
NATURAL MOISTURE CONTENT WEATHERED AND INTACT DICRANOGRAPTUS BEDS FORMATION
263826-00

FIGURE 39

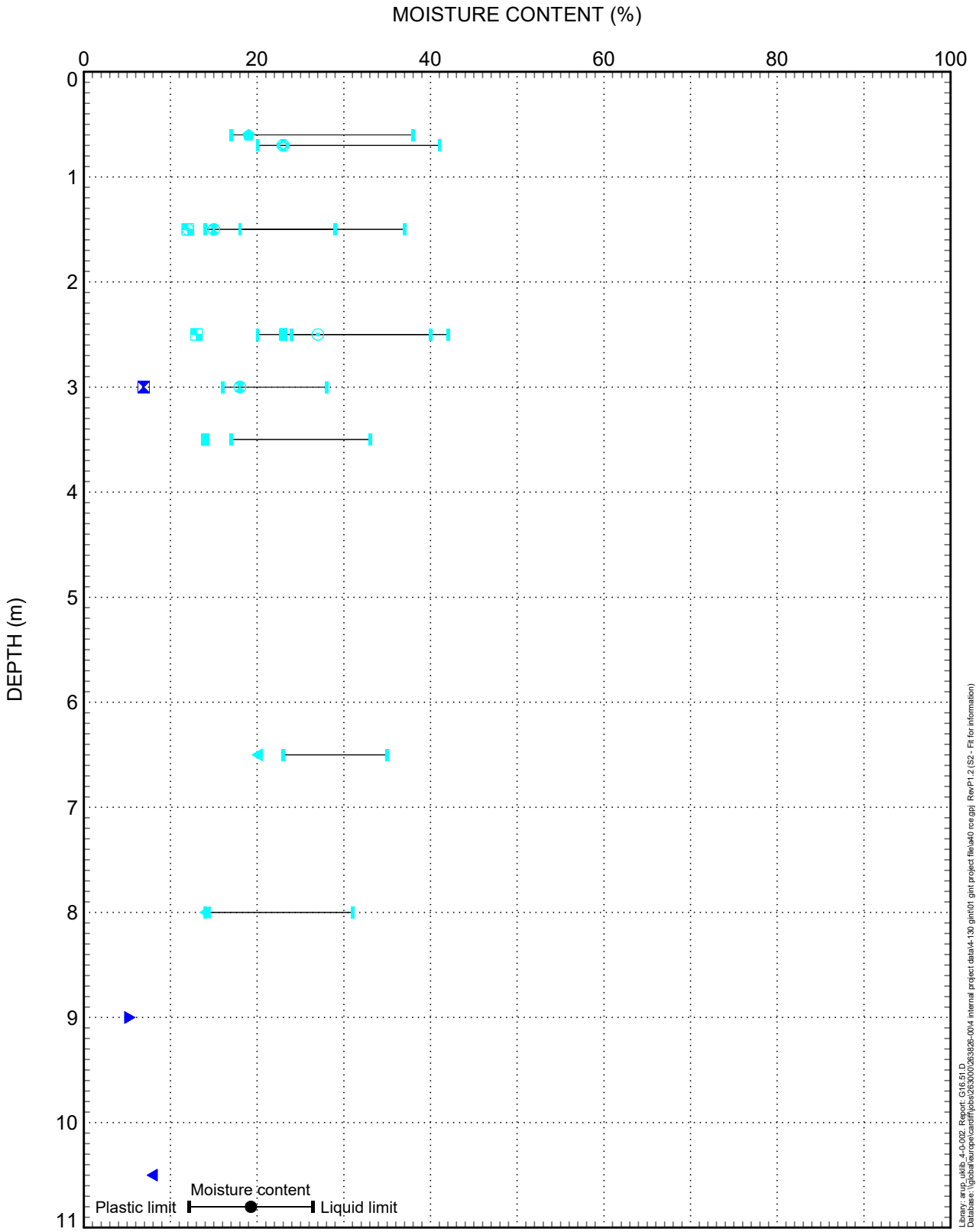


- Weathered Dicranograptus Beds Formation (WDB)
- RCEBH07, 6.50m, 21
- RCEBH07, 8.00m, 23
- RCEDS06a, 0.60m, 1
- RCEDS06a, 0.60m, 2
- RCEDS10, 0.70m, 1
- RCETP08, 2.50m, 6
- RCETP08, 3.50m, 7
- RCETP10, 2.50m, 5
- RCETP11, 1.50m, 5
- RCETP12, 1.50m, 6
- RCETP12, 3.00m, 8

A40 REDSTONE CROSS IMPROVEMENTS
PLASTICITY CHART
WEATHERED AND INTACT DICRANOGRAPTUS BEDS FORMATION
263826-00

FIGURE 40

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20



Weathered Dicranograptus Beds Formation (WDB)
Dicranograptus Beds Formation (DB)
RCEBH07
RCEBH08
RCEBH09
RCEDS06a
RCEDS10
RCETP08
RCETP10
RCETP11
RCETP12

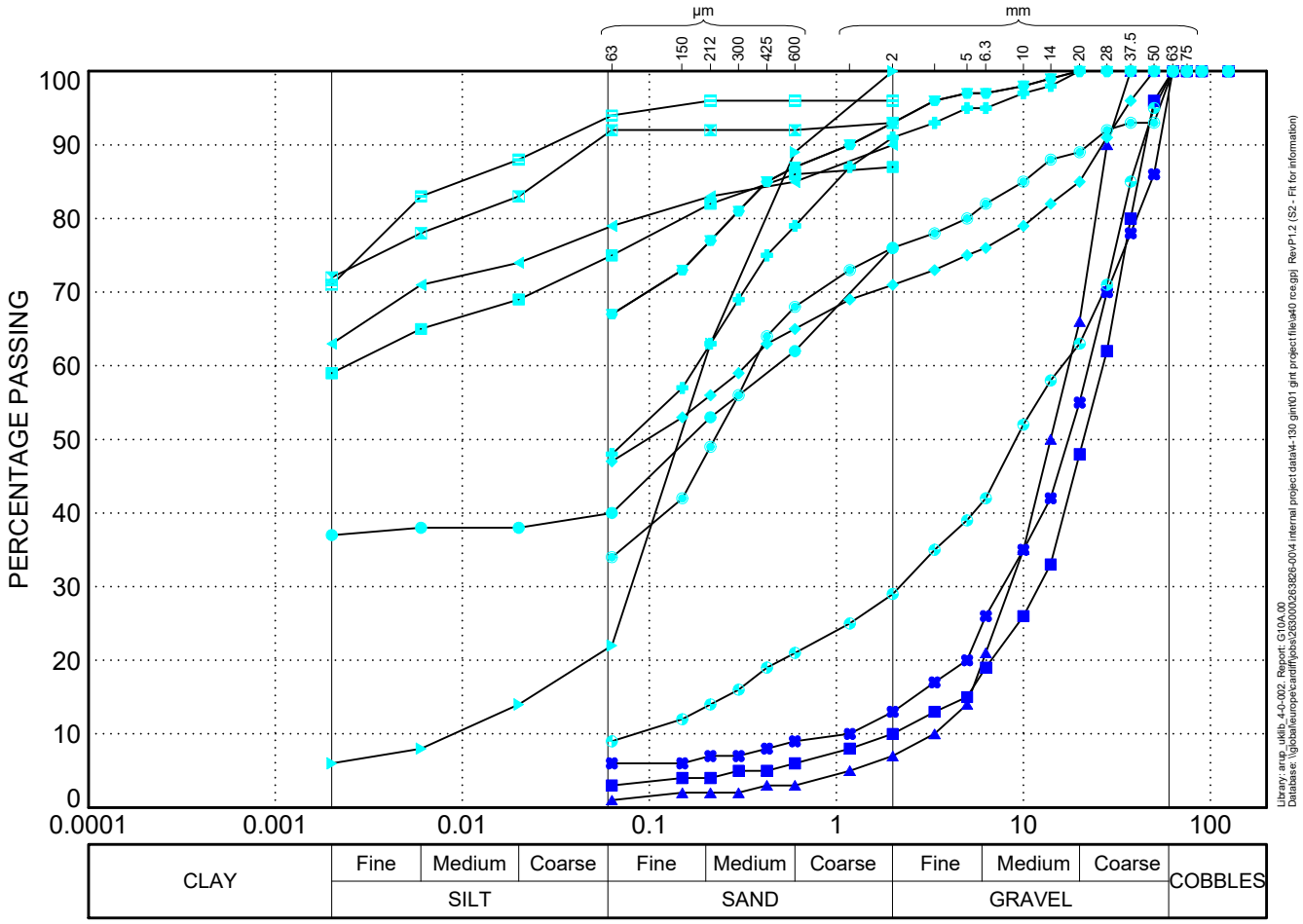
Library: arup_uklib_4-0-002, Report: G16.51.D
Database: \\global\europe\cardiff\jobs\263000\263826-00\4 internal project data\4-130 gint\01 gint project files\a40 rce.gpj Rev:P1.2 (S2 - Fit for information)

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
ATTERBERG LIMITS
WEATHERED AND INTACT DICRANOGRAPTUS BEDS FORMATION
263826-00

FIGURE 41



- Weathered Dicranograptus Beds Formation (WDB)
- Dicranograptus Beds Formation (DB)
- RCEBH07, 6.50m, 21
- RCEBH07, 10.50m
- RCEBH08, 9.00m
- RCEBH09, 3.00m
- RCEDS06a, 0.60m, 1
- RCEDS06a, 0.60m, 2
- RCEDS10, 0.70m, 1
- RCETP08, 2.50m, 6
- RCETP08, 3.50m, 7
- RCETP10, 1.50m, 6
- RCETP10, 2.50m, 5
- RCETP11, 1.50m, 5
- RCETP11, 2.50m, 6
- RCETP12, 1.50m, 6
- RCETP12, 3.00m, 8

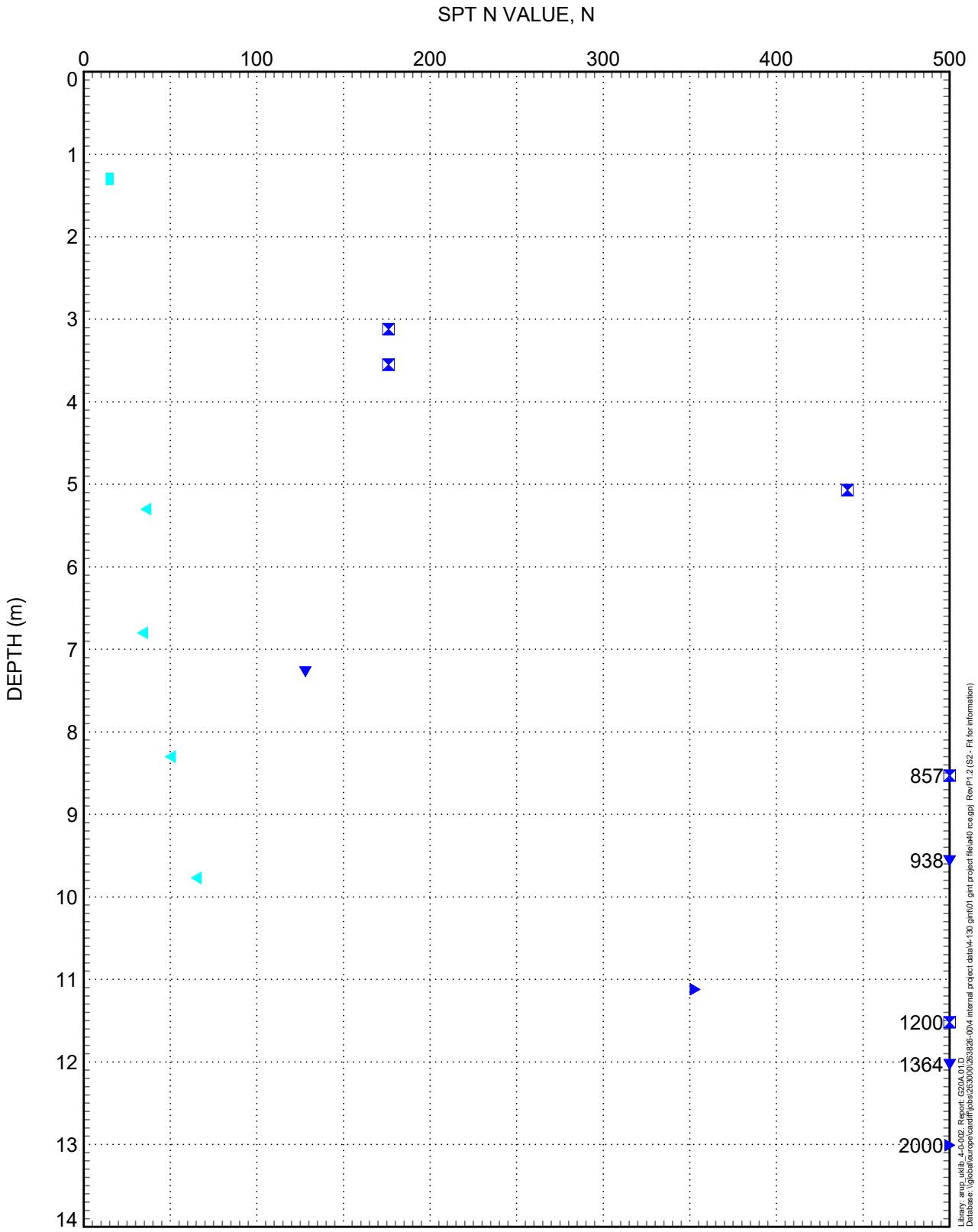
A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION WEATHERED AND INTACT DICRANOGRAPTUS BEDS FORMATION

263826-00

FIGURE 42

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



- Weathered Dicranograptus Beds Formation (WDB)
- Dicranograptus Beds Formation (DB)
- RCEBH05 ROT
- RCEBH07
- RCEBH08
- RCEBH09
- RCEDS09

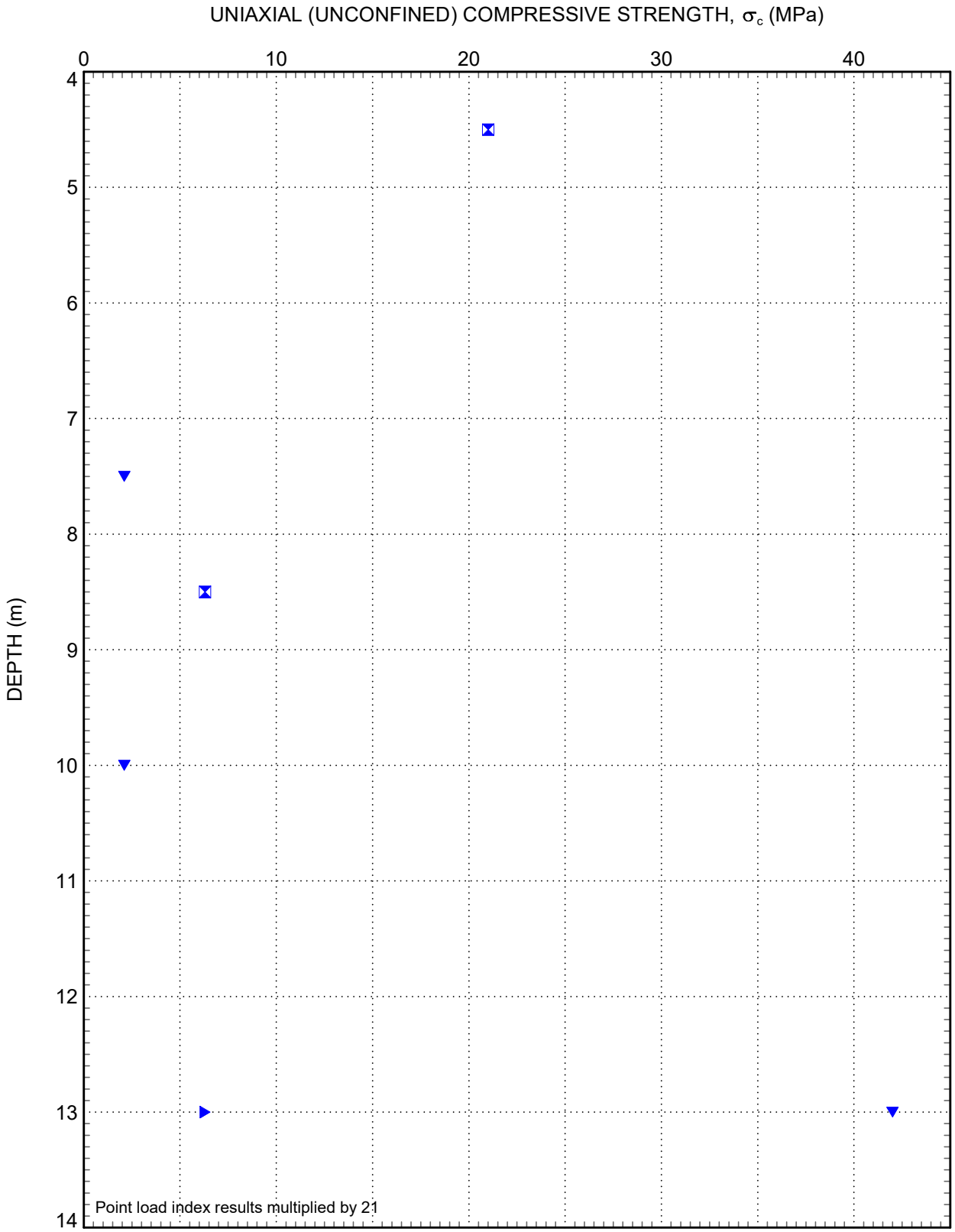
A40 REDSTONE CROSS IMPROVEMENTS
STANDARD PENETRATION TESTS WEATHERED AND INTACT DICRANOGRAPTUS BEDS FORMATION

263826-00

FIGURE 43

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



- Dicranograptus Beds Formation (DB)
- RCEBH05 ROT
- RCEBH08
- RCEBH09

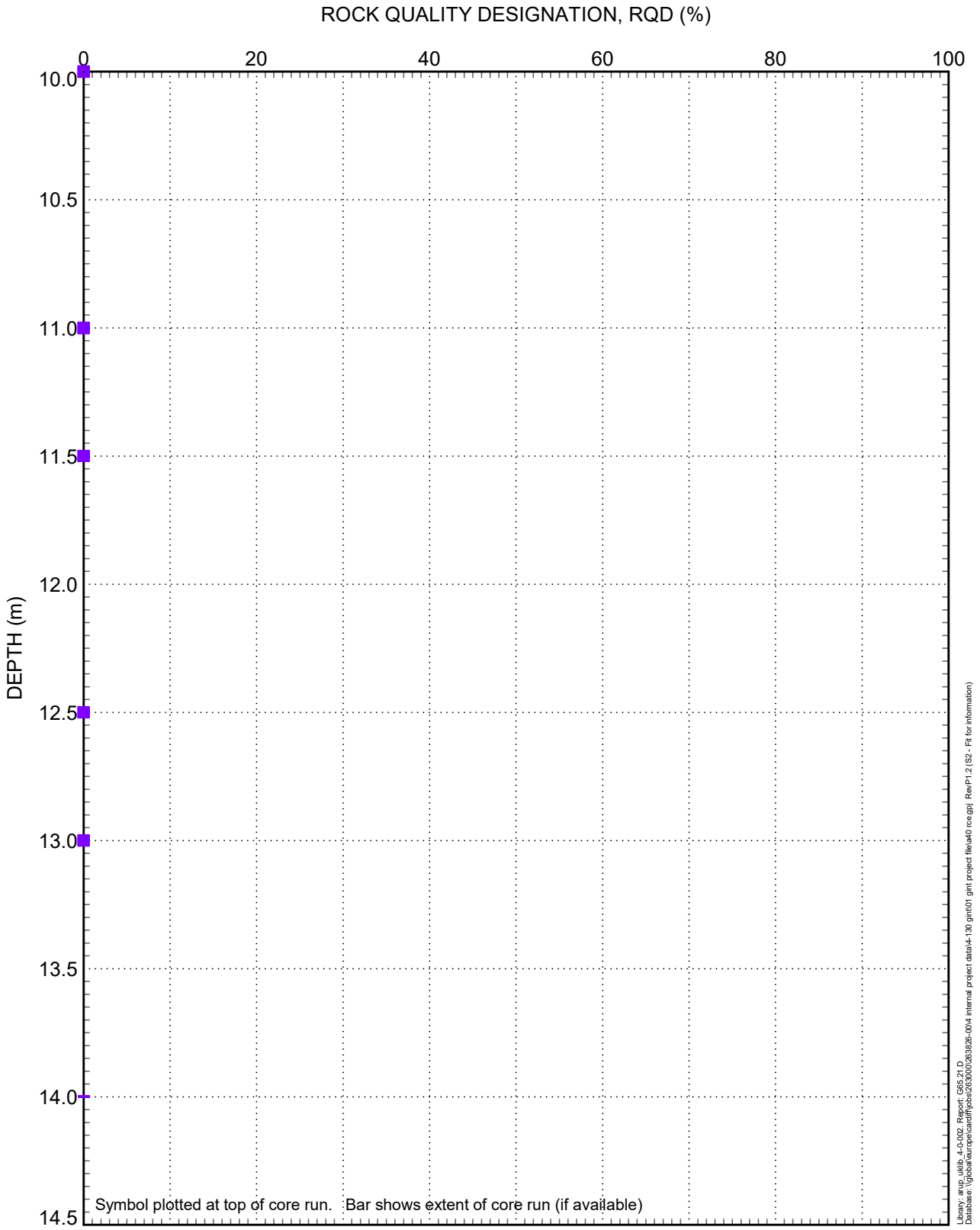
A40 REDSTONE CROSS IMPROVEMENTS
UCS FROM POINT LOAD TESTS
INTACT DICRANOGRAPTUS BEDS FORMATION

263826-00

FIGURE 44

ARUP, gINT v6.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



Llandeilo Limestone Formation (LL)
RCEBH06

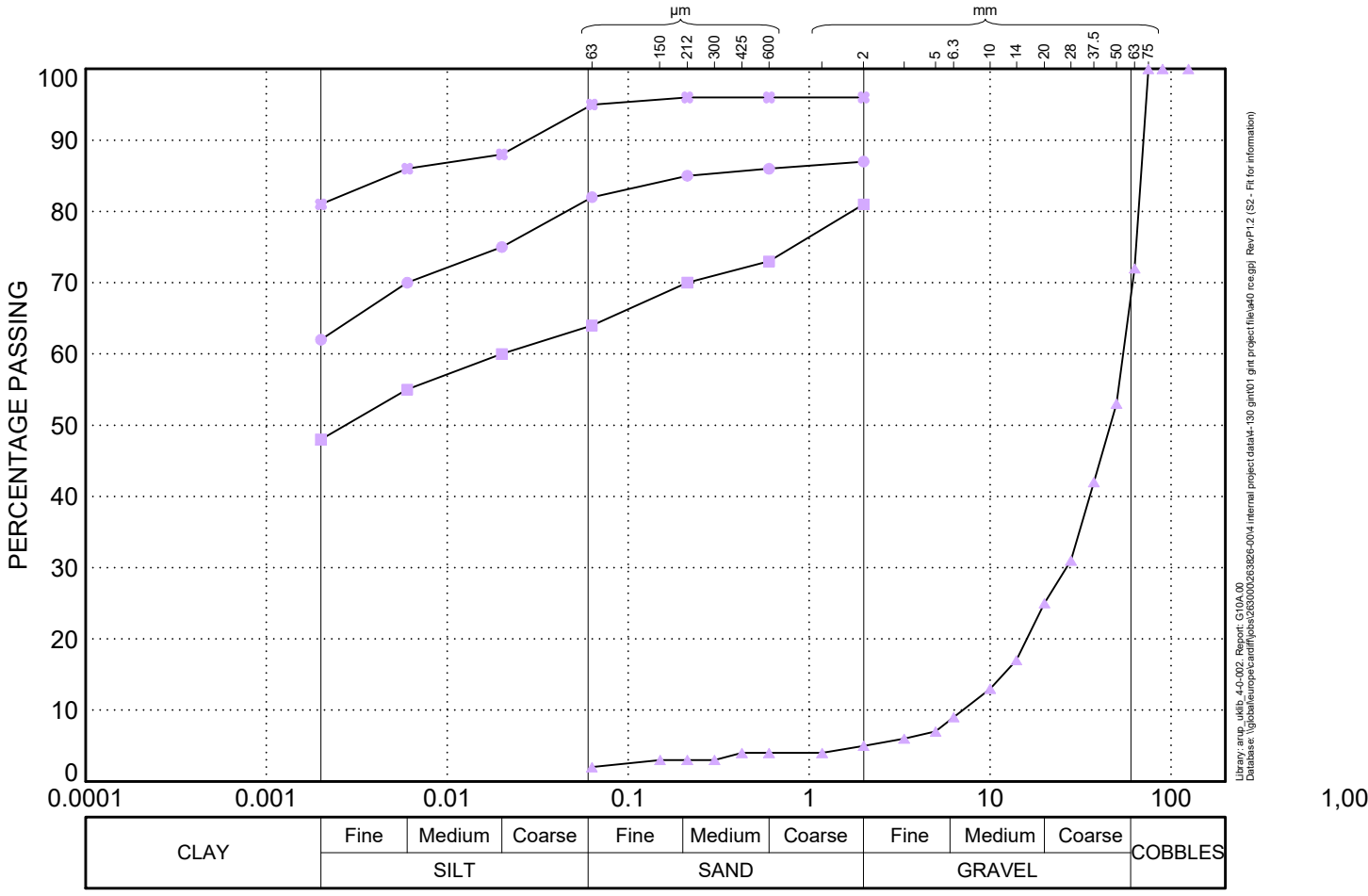
A40 REDSTONE CROSS IMPROVEMENTS
ROCK QUALITY DESIGNATION INTACT LLANDEILO LIMESTONE

263826-00

FIGURE 45

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None



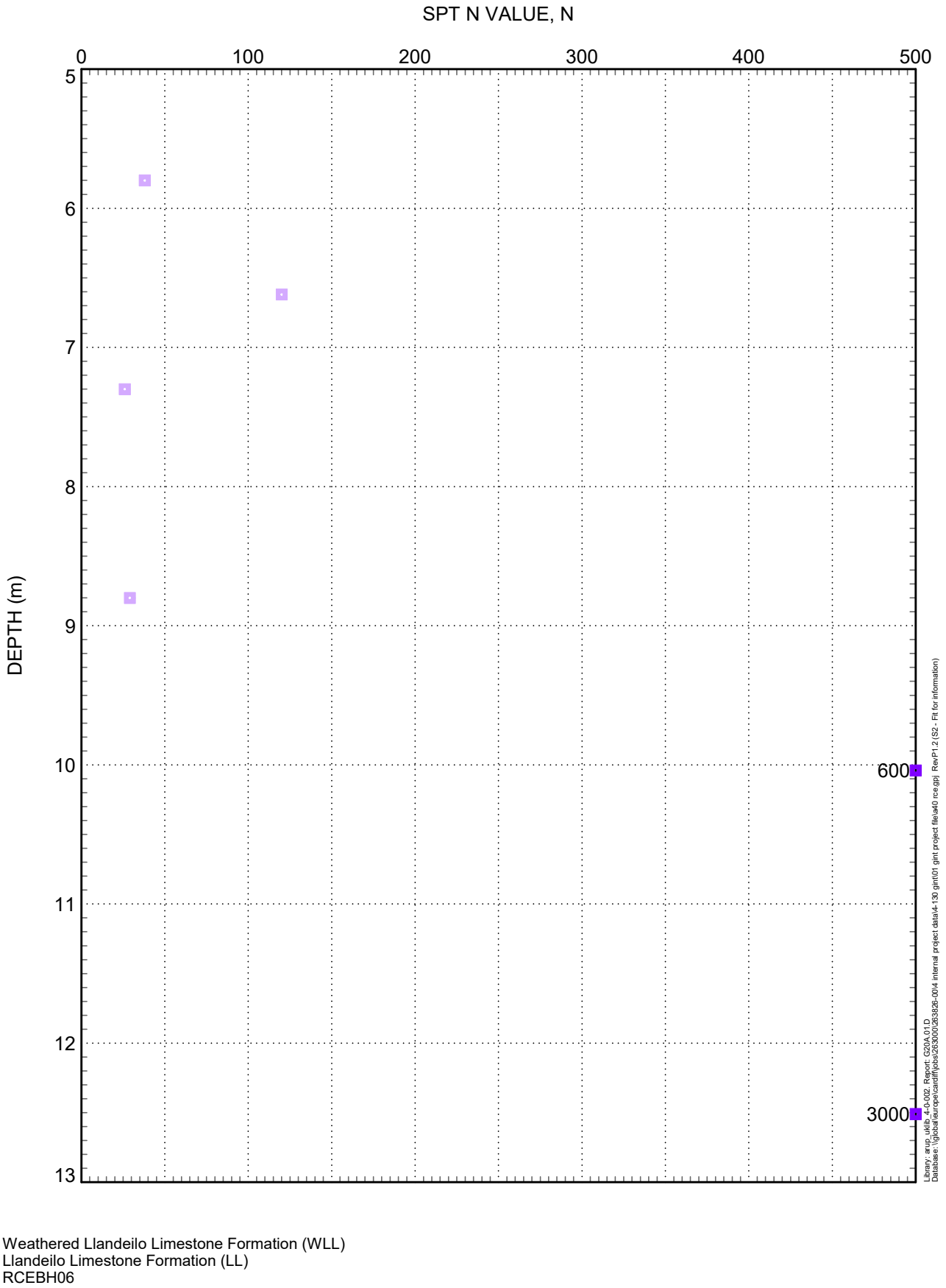
- Weathered Llandeilo Limestone Formation (WLL)
- RCEBH06, 5.00m, 20
- RCEBH06, 6.30m, 23
- RCEBH06, 9.00m
- RCETP09, 2.50m, 6

A40 REDSTONE CROSS IMPROVEMENTS
PARTICLE SIZE DISTRIBUTION WEATHERED LLANDEILO LIMESTONE

263826-00

FIGURE 46

ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20



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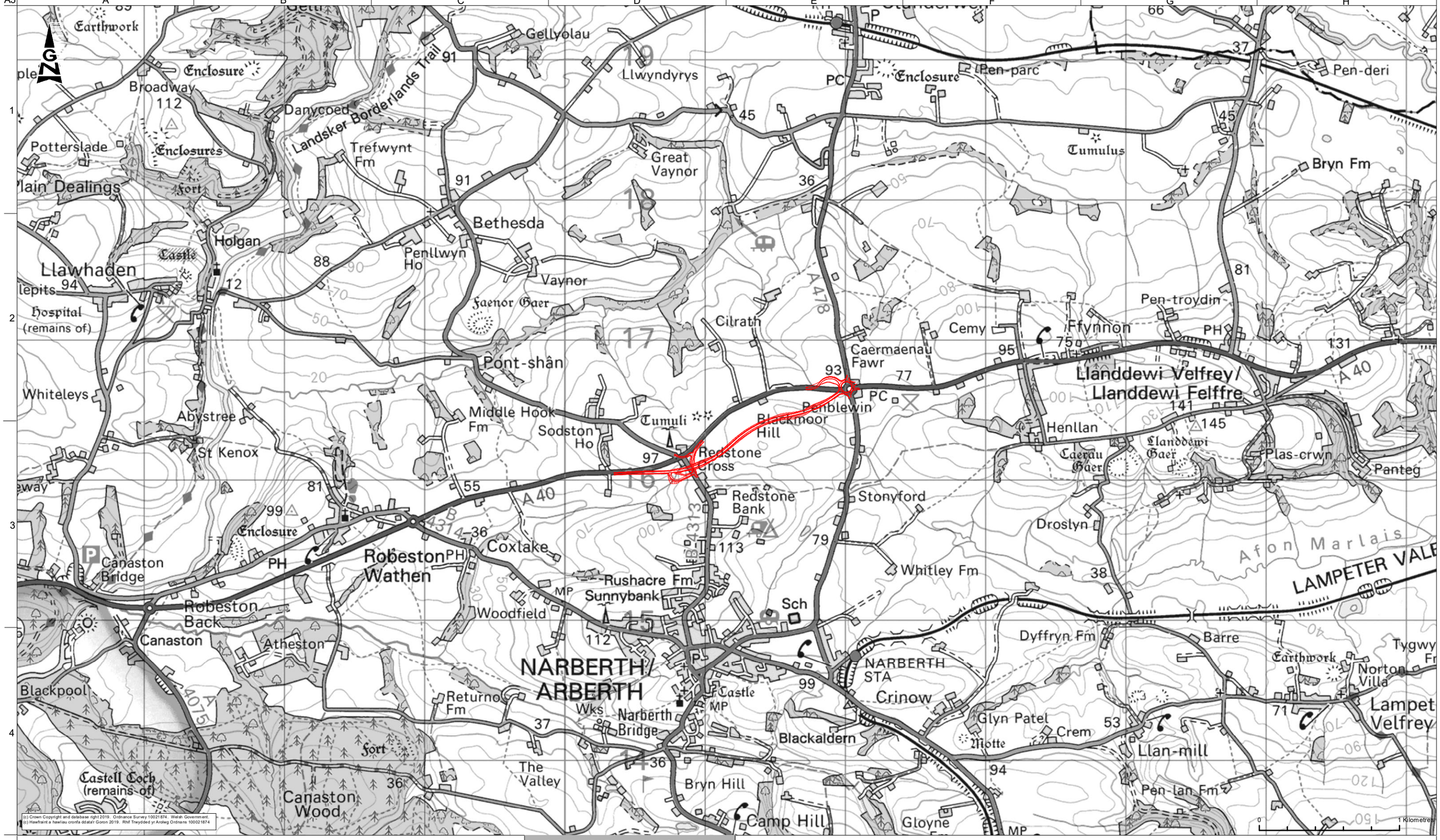
ARUP, gINT v8.30.003
Made by Aodhan Teague on 24-Feb-20

| None | None

A40 REDSTONE CROSS IMPROVEMENTS
STANDARD PENETRATION TESTS WEATHERED AND INTACT LLANDEILO LIMESTONE

263826-00

FIGURE 47



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LEGEND

A40 PENBLEWIN ROUNDABOUT TO REDSTONE CROSS PREFERRED ALIGNMENT

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction

None

Maintenance / Cleaning

None

Use

None

Decommissioning / Demolition

None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	09/04/20	SECOND ISSUE	AC	CB	RC	GD
P01	25/02/20	FIRST ISSUE	AC	CB	RC	GD

Project Title

A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

Client

Llywodraeth Cymru
Welsh Government

Delivery Team

ARCADIS
MOTT MACDONALD
ARUP
RICHARDS

Drawing Title

DRAWING 1
SITE LOCATION PLAN

Suitability

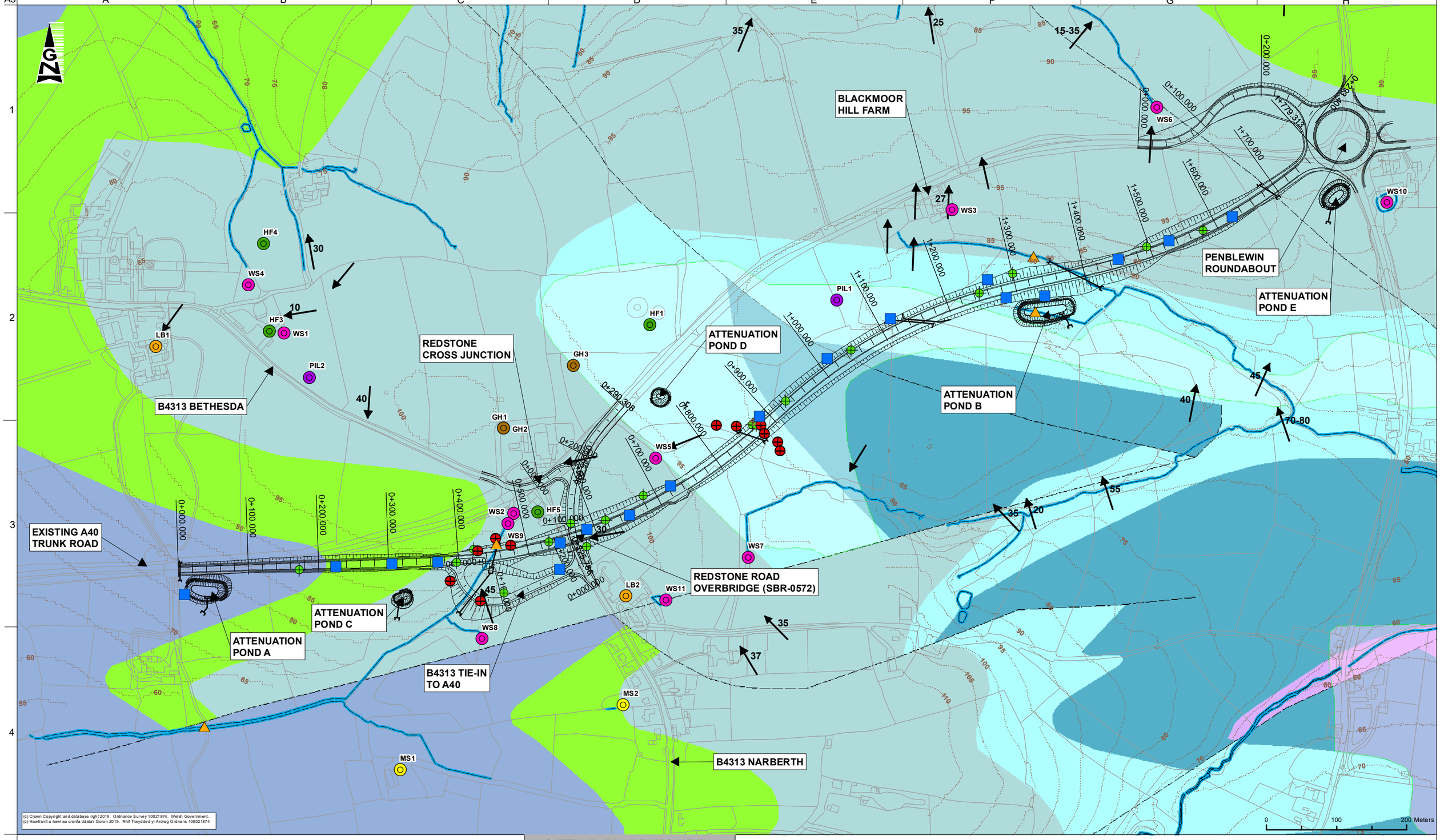
S4 | **SUITABLE FOR STAGE APPROVAL**

Scale at A3 1:25,000

Rev	By	Chkd	Appd	Auth
P02	AC	CB	RC	GD
	Date	Date	Date	Date
	09/04/20	09/04/20	09/04/20	09/04/20

Name

Project	Originator	Volume	Location	Type	Role	Number
A40PRC	ARP	EGT	SWI	DR	LE	0001



LEGEND

PREFERRED ALIGNMENT
WATERBODIES
2019 GI (AS BUILT)
BOREHOLE
DYNAMIC SAMPLE
SURFACE WATER SAMPLE
TRIAL PIT

HISTORICAL FEATURES
GROUND HAZARD
HISTORICAL FEATURE
LISTED BUILDING
MINERAL SITE
POTENTIALLY INFILLED LAND
WATER SOURCE

GEOLOGY
GLACIAL TILL
HAVERFORD BEDS (CETHINGS SANDSTONE)
HAVERFORD BEDS (GASWORKS MUDSTONE)
LLANDEILO LIMESTONE FORMATION
MYDRIM SHALES (DICRANOGRAPTUS BEDS FORMATION)
SLADE AND REDHILL
BEDROCK DIP ANGLE AND DIRECTION (INFERRED FROM 1:10,560 1907 MAP)
GEOLOGICAL FAULT

Note 1: Refer to drawings A40PRC-ARP-EGT-SWI-DR-LE-0004 and A40PRC-ARP-EGT-SWI-DR-LE-0005 for GI details.
Note 2: See Appendix A of A40PRC-ARP-HGT-M02-RP-C-0006 for Historical Features details.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	09/04/20	LEGEND AMENDMENT	AC	CB	RC	GD
P01	25/02/20	FIRST ISSUE	AC	CB	RC	GD

Project Title
A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

ARCADIS
MOTT MACDONALD

Delivery Team
ARUP
RICHARDS PARTNERSHIP

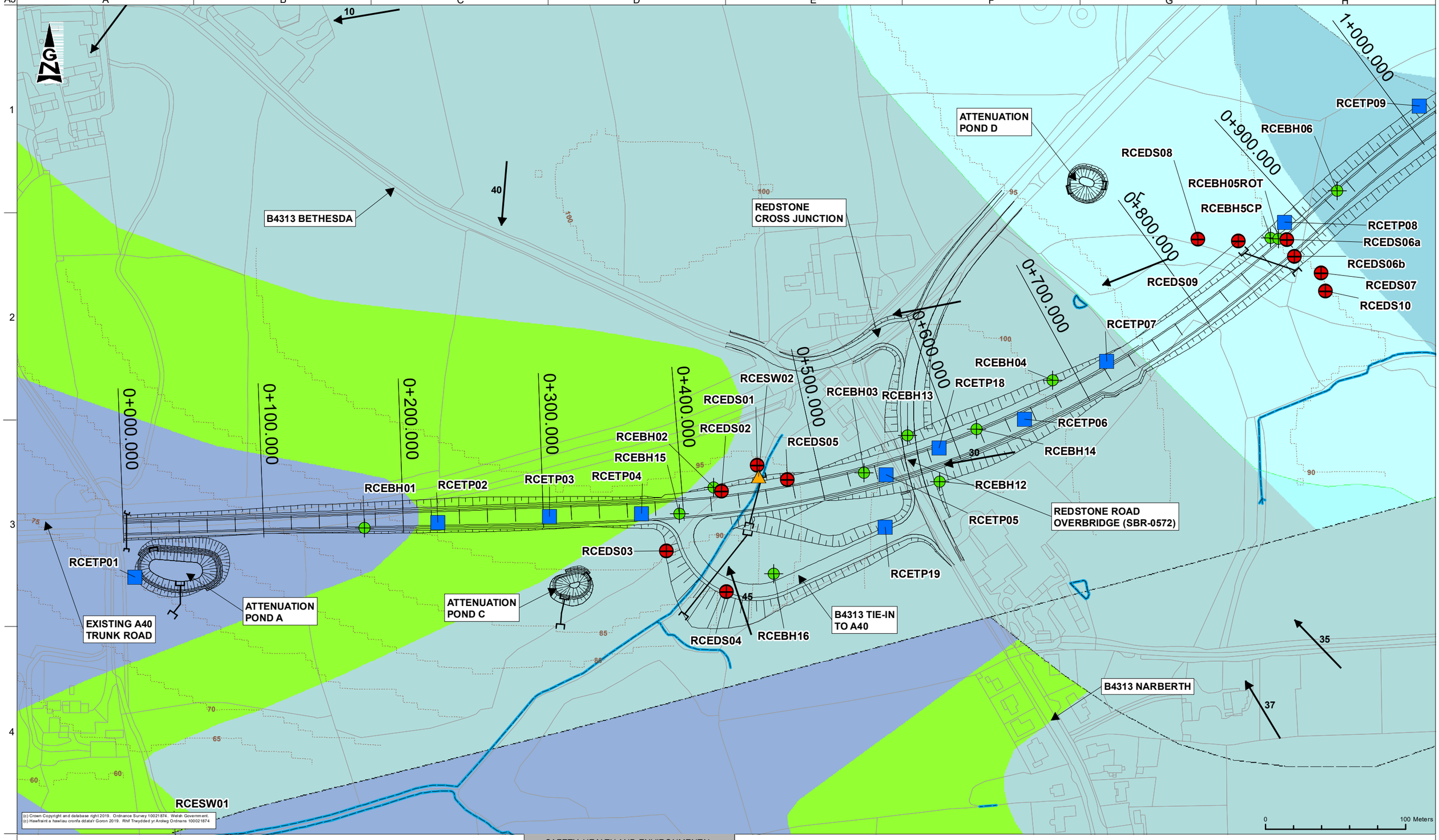
Drawing Title
DRAWING 2
GEOTECHNICAL FEATURES AND CONSTRAINTS PLAN

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A3
1:5,000

Rev	By	Chkd	Appd	Auth
P02	AC	CB	RC	GD
	Date 09/04/20	Date 09/04/20	Date 09/04/20	Date 09/04/20

Name
A40PRC - ARP - EGT - SWI - DR - LE - 0002
Project | Originator | Volume | Location | Type | Role | Number



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LEGEND

- PREFERRED ALIGNMENT
- WATERBODIES

2019 GI (AS BUILT)

- BOREHOLE
- DYNAMIC SAMPLE
- SURFACE WATER SAMPLE
- TRIAL PIT

GEOLOGY

- GLACIAL TILL
- HAVERFORD BEDS (CETHINGS SANDSTONE)
- HAVERFORD BEDS (GASWORKS MUDSTONE)
- LLANDEILO LIMESTONE FORMATION
- MYDRIM SHALES (DICRANOGRAPTUS BEDS FORMATION)
- SLADE AND REDHILL
- BEDROCK DIP ANGLE AND DIRECTION (INFERRED FROM 1:10,560 1907 MAP)
- GEOLOGICAL FAULT

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	09/04/20	LEGEND AMENDMENT	AC	CB	RC	GD
P01	25/02/20	FIRST ISSUE	AC	CB	RC	GD

Project Title
A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

Delivery Team
ARCADIS
MOTT MACDONALD
ARUP
RICHARDS

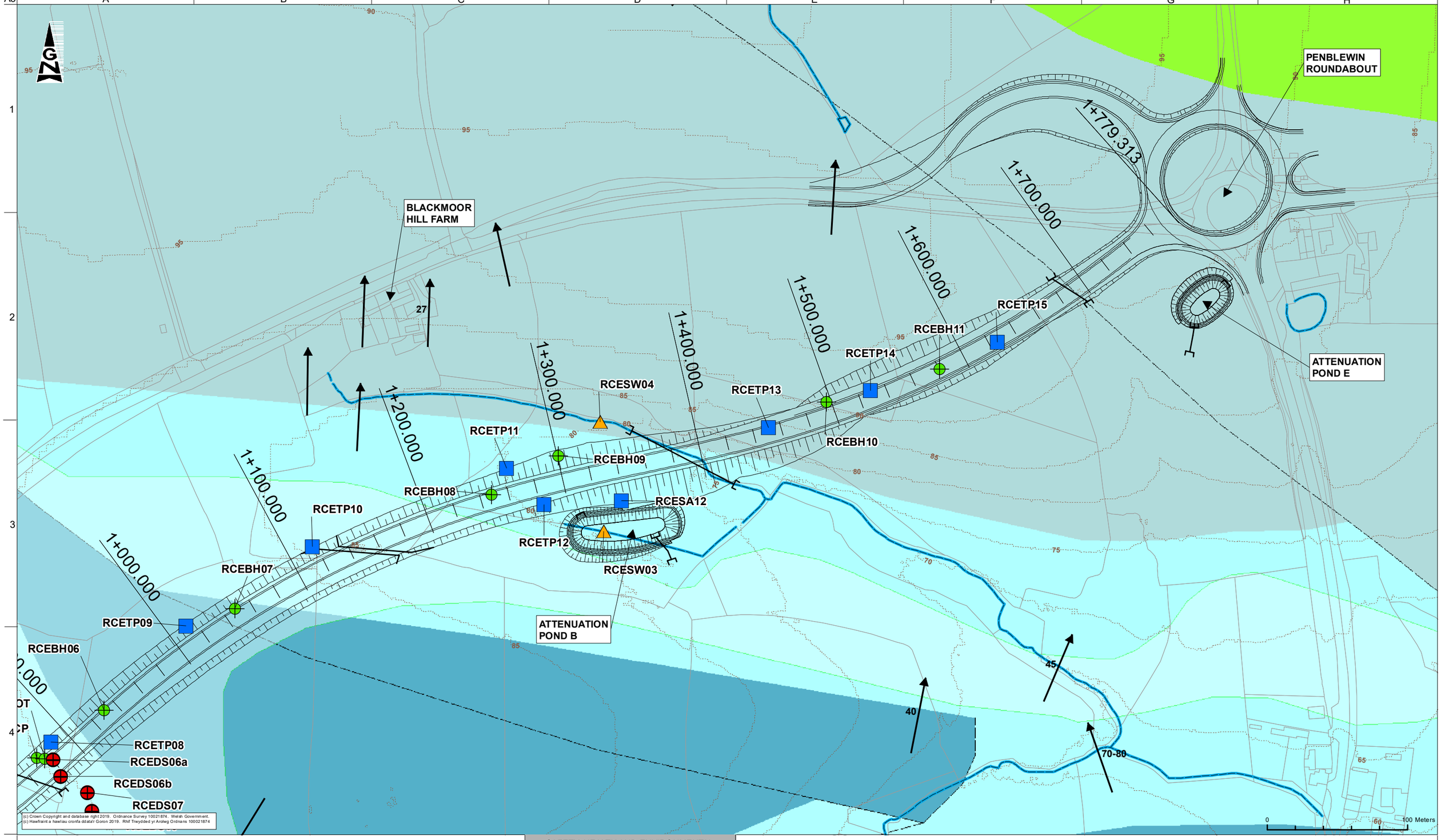
Drawing Title
DRAWING 3
GROUND INVESTIGATION
LOCATION PLAN (WEST SECTION)

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A3
1:2,500

Rev	By	Chkd	Appd	Auth
P02	AC	CB	RC	GD
	Date 09/04/20	Date 09/04/20	Date 09/04/20	Date 09/04/20

Name
A40PRC - ARP - EGT - SWI - DR - LE - 0004
Project | Originator | Volume | Location | Type | Role | Number



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LEGEND

- PREFERRED ALIGNMENT
- WATERBODIES

2019 GI (AS BUILT)

- BOREHOLE
- DYNAMIC SAMPLE
- SURFACE WATER SAMPLE
- TRIAL PIT

GEOLOGY

- GLACIAL TILL
- HAVERFORD BEDS (CETHINGS SANDSTONE)
- HAVERFORD BEDS (GASWORKS MUDSTONE)
- LLANDEILO LIMESTONE FORMATION
- MYDRIM SHALES (DICRANOGRAPTUS BEDS FORMATION)
- SLADE AND REDHILL FORMATION
- BEDROCK DIP ANGLE AND DIRECTION (INFERRED FROM 1:10,560 1907 MAP)
- GEOLOGICAL FAULT

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log)

Construction
None

Maintenance / Cleaning
None

Use
None

Decommissioning / Demolition
None

Rev.	Date	Description	By	Chkd	Appd	Auth
P02	09/04/20	LEGEND AMENDMENT	AC	CB	RC	GD
P01	25/02/20	FIRST ISSUE	AC	CB	RC	GD

Project Title
A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

Delivery Team
ARCADIS
MOTT MACDONALD
ARUP
RICHARDS

Drawing Title
DRAWING 4
GROUND INVESTIGATION
LOCATION PLAN (EAST SECTION)

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A3 1:2,500

Rev	By	Chkd	Appd	Auth
P02	AC	CB	RC	GD
	Date 09/04/20	Date 09/04/20	Date 09/04/20	Date 09/04/20

Name
A40PRC - ARP - EGT - SWI - DR - LE - 0005
Project | Originator | Volume | Location | Type | Role | Number

Appendix A

Summary of Site Features and Constraints

Table A 1 Notation of key site features and constraints referenced and shown on the Features and Constraints Plans (Drawing 2 – A40PRC-ARP-EGT-SWI-DR-LE-0002)

Notation	Feature	Description	Source of information	Easting	Northing
HF1	Historical Feature - Tumuli	Ancient burial mound which is recorded as scheduled monuments	CADW	211022	216394
HF2	Historical Feature – Former Marsh	Shown on the 1961 map, no longer shown	Historical Maps	211533	216888
HF3	Historical Feature - Quarry	Shown from 1888 to 1907 maps. After this, it is noted as "old quarry"	Historical Maps	210479	216385
HF4	Historical Feature - Reservoir	shown from 1888 to 1971 maps, it is then no longer shown	Historical Maps	210471	216510
HF5	Historical Feature - Garage	Redstone Forge Garage is now shown to be inactive	Landmark Envirocheck Report	210862	216127
GH1	Ground Hazard - Potential for Landslide Ground Stability Hazards	No evidence of ground stability noted during the site visit	Landmark Envirocheck Report	210813	216246
GH2	Ground Hazard - Potential for Shrinking or Swelling Clay Ground Stability Hazards	No evidence of ground stability noted during the site visit	Landmark Envirocheck Report	210813	216246
GH3	Ground Hazard - Potential for Running Sand Ground Stability Hazards	No evidence of ground stability noted during the site visit	Landmark Envirocheck Report	210913	216336
WS1	Water source - Pond	Located near historical quarry (HF3)	Landmark Envirocheck Report and Historical Maps	210500	216382
WS2	Water source - Well	May be associated with the nearby tributary of Narberth Brook	Envirocheck Report and Historical Maps	210828	216125
WS3	Water source - Spring	Headwaters of unnamed tributaries of Afon Marlais	Landmark Envirocheck Report and Historical Maps	211453	216558
WS4	Water source - Spring	Noted on 1953 map. No longer shown	Historical Maps	210449	216451

Notation	Feature	Description	Source of information	Easting	Northing
WS5	Water source - Pond	Noted as a potential excavation from 1950-80, first noted in 1970 historical map	Landmark Envirocheck Report	211030	216204
WS6	Water source - Pond	Headwaters of unnamed tributary of Longford Brook	Landmark Envirocheck Report	211745	216704
WS7	Water source – Collects	Headwaters of unnamed tributaries of Afon Marlais	Environmental Statement	211163	216061
WS8	Water source – Issues	Headwaters of unnamed tributaries of Narbeth Brook	Environmental Statement	210782	215947
WS9	Water source – Spring	Headwaters of unnamed tributaries of Narbeth Brook	Environmental Statement	210817	216109
WS10	Water source – Pond	None available	Environmental Statement	212072	216568
WS11	Water source – Pond	None available	Environmental Statement	211043	216001
LB1	Listed Building - Sodstone House	None available	CADW	210317	216363
LB2	Listed Building - Blaen Marlais	None available	CADW	210988	216007
PIL1	Potentially infilled land (water)	Unknown use. Noted in 1961 maps	Landmark Envirocheck Report	211289	216429
PIL2	Potentially infilled land (water)	Unknown use. Noted in 1961 maps. Satellite imagery shows it to remain a pond.	Landmark Envirocheck Report	210536	216319
MS1	BGS recorded mineral site	Active opencast extraction of *"Portfeild Formation and Haverford Mudstone Formation"*	Landmark Envirocheck Report	210666	215759
MS2	BGS recorded mineral site	Ceased opencast extraction of Slade and Redhill Formation	Landmark Envirocheck Report	210984	215852

Appendix B

RocLab Output

RocLab Output - Intact Slade and Redhill Formation

Analysis of Rock Strength using RocLab

Refer to text for UCS and GSI determination

MR based on marl (encountered as mudstone in logs)

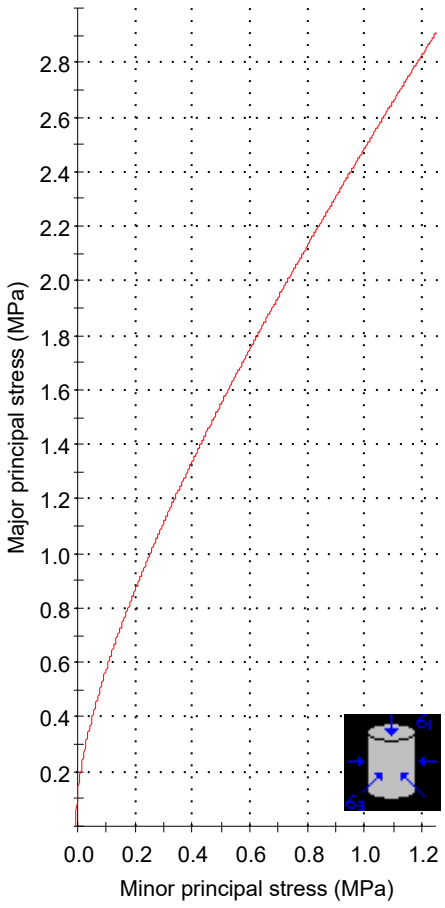
Disturbance Factor based on mechanically excavated slope

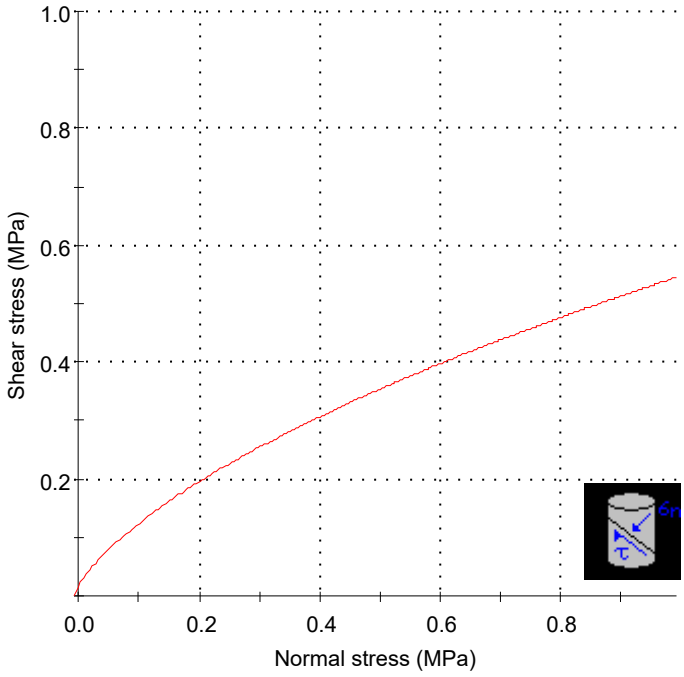
Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 5 MPa
GSI = 50 mi = 7 Disturbance factor (D) = 0.7
intact modulus (Ei) = 875 MPa
modulus ratio (MR) = 175

Hoek-Brown Criterion
mb = 0.449 s = 0.0007 a = 0.506

Mohr-Coulomb Fit
cohesion = 0.154 MPa friction angle = 20.28 deg

Rock Mass Parameters
tensile strength = -0.008 MPa
uniaxial compressive strength = 0.128 MPa
global strength = 0.443 MPa
deformation modulus = 93.87 MPa





RocLab Output - Dicranograptus Beds

Analysis of Rock Strength using RocLab

Refer to text for UCS and GSI determination

MR based on marl (encountered as mudstone in logs)

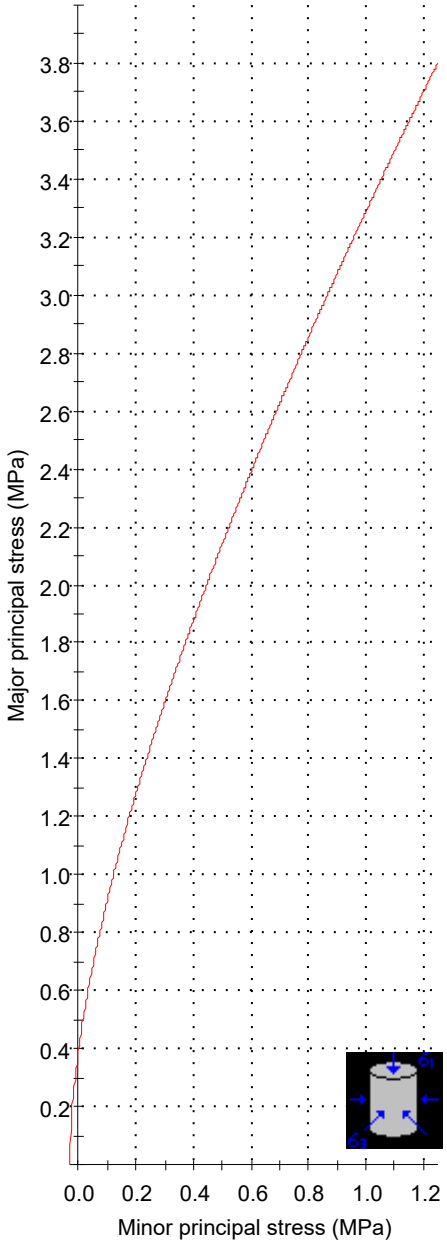
Disturbance Factor based on mechanically excavated slope

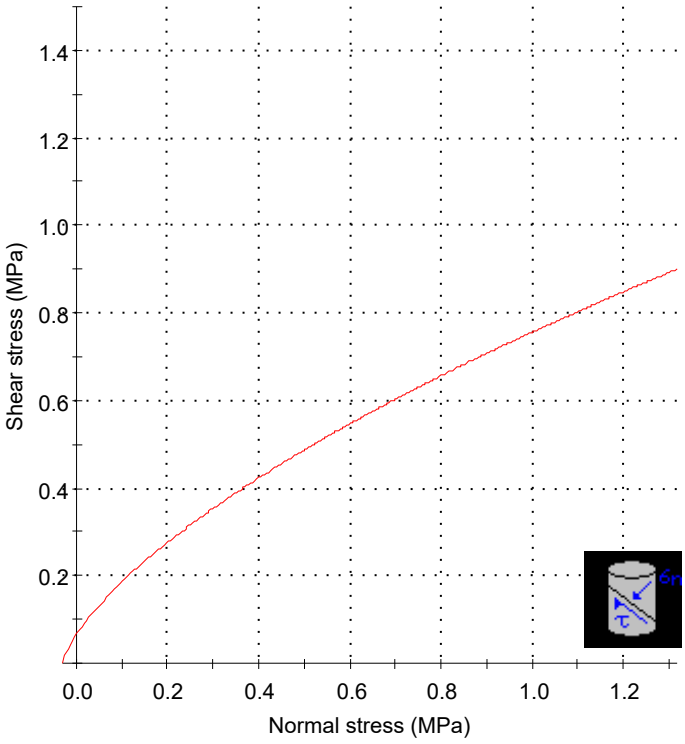
Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 5 MPa
GSI = 65 mi = 7 Disturbance factor (D) = 0.7
intact modulus (Ei) = 875 MPa
modulus ratio (MR) = 175

Hoek-Brown Criterion
mb = 1.023 s = 0.0063 a = 0.502

Mohr-Coulomb Fit
cohesion = 0.225 MPa friction angle = 26.36 deg

Rock Mass Parameters
tensile strength = -0.031 MPa
uniaxial compressive strength = 0.392 MPa
global strength = 0.726 MPa
deformation modulus = 232.23 MPa





RocLab Output - Llandeilo Limestone Formation

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial comp. strength (sigci) = 5 MPa
GSI = 65 mi = 7 Disturbance factor (D) = 0.7
intact modulus (Ei) = 875 MPa
modulus ratio (MR) = 175

Hoek-Brown Criterion
mb = 1.023 s = 0.0063 a = 0.502

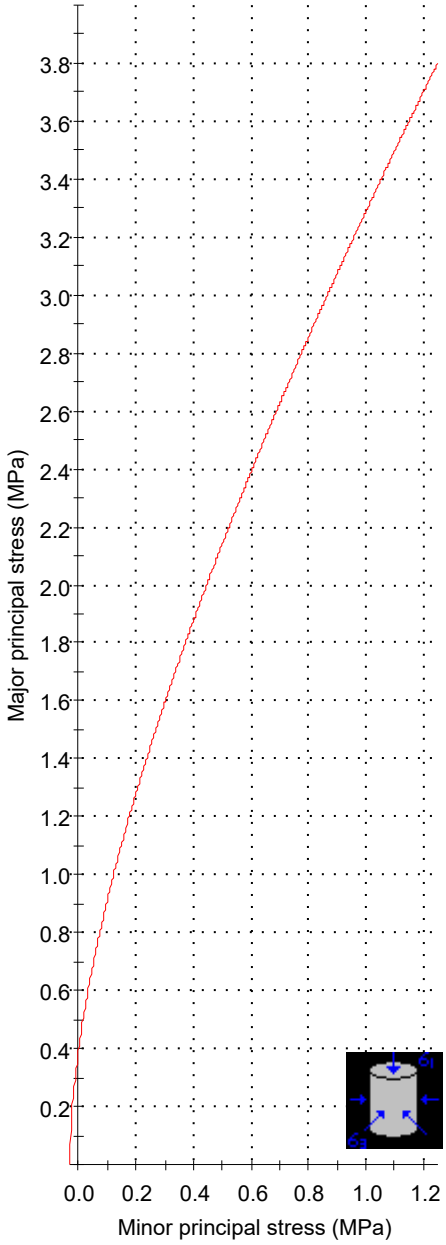
Mohr-Coulomb Fit
cohesion = 0.225 MPa friction angle = 26.36 deg

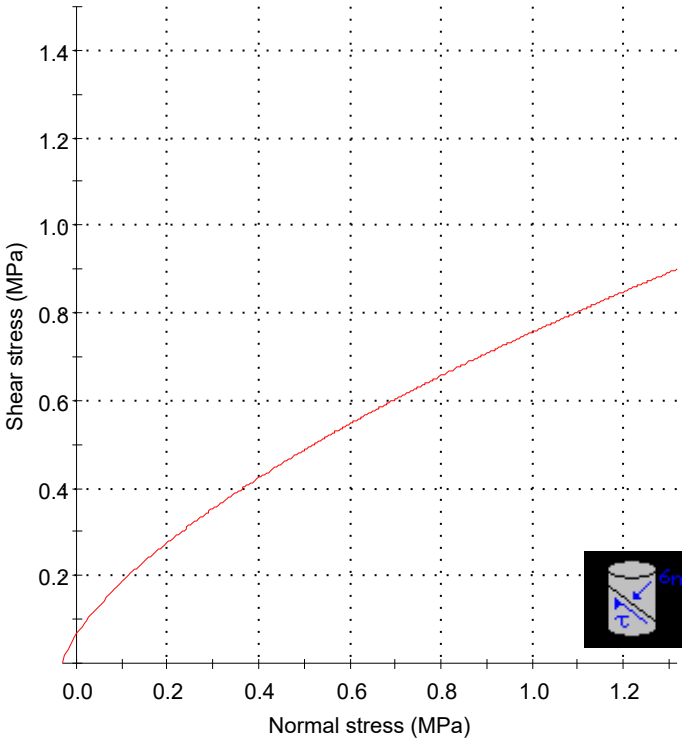
Rock Mass Parameters
tensile strength = -0.031 MPa
uniaxial compressive strength = 0.392 MPa
global strength = 0.726 MPa
deformation modulus = 232.23 MPa

Refer to text for UCS and GSI determination

MR based on Siltstone (encountered as siltstone in logs)

Disturbance Factor based on mechanically excavated slope





Appendix C

Detailed Geo-environmental Assessment Methodology

C1 Detailed methodology for assessment of baseline scenarios

C1.1.1 The UK legislation on ground contamination 'Part 2A Environmental Protection Act, 1990' [31] describes a risk assessment methodology in terms of "significant pollutants" and "significant pollutant linkages" within a contaminant-pathway-receptor (CPR) model of the site. The model comprises:

a) The principal pollutant hazards associated with the site (the contaminants);

b) The principal receptors at risk from the identified hazards; and

c) The existence, or absence, of plausible pathways which may exist between the identified sources and receptors.

C1.1.2 For land to be determined as contaminated and require remediation (or possibly a change to less sensitive use), all three elements (contaminant-pathway-receptor) of a significant pollutant linkage must be present.

C1.1.3 The baseline contamination Conceptual Site Model (CSM) for the proposed scheme has been derived based on a review of the available desk study information; i.e. historical maps, geological maps, OS maps and online resources.

C1.1.4 Potential sources and receptors of contamination and plausible pollution linkages have been considered on a case by case basis. Potential sources of contamination within 250m of the proposed alignment have been considered in the assessment of human health and controlled waters.

C1.1.5 Sensitive receptors have been identified based on the review of the existing information to assess the risks posed by potentially contaminated land. Identified receptors include:

a) Sensitive human receptors; and

b) Controlled waters (groundwater and surface water) that may be affected by contaminants.

C1.1.6 Potential sources of contamination have been identified based on the review of existing information, including the results of contamination testing from intrusive investigations completed to date. These include:

a) Historic industrial/commercial activities;

b) Current industrial/commercial activities;

c) Possible or known areas of made ground;

d) Locations of pollution incidents or licensed discharges; and

e) Review of past and present environmental permits, processes, licences.

C1.1.7 Potential pathways through which the contamination from identified sources may reach the sensitive receptors have been based on the review of the study information, construction activities, end land use and ground investigation information; relevant pathways include:

a) Ingestion, inhalation, or dermal contact with soils/dust originating from the sources of contamination;

b) Inhalation of ground gasses/hydrocarbon vapours originating from sources of contamination; and

c) Leaching and migration of contamination.

Detailed methodology for assessment of potential construction impacts

C1.1.8 A review of the baseline data identified and refined the extent of potentially contaminated land within the vicinity of the proposed alignment. The need for further focussed assessment was considered where existing or suspected contamination may be affected by the scheme, i.e. by creating or altering pollutant linkages between sources and sensitive receptors. Those contamination sources identified fully outside of the study area are only considered if a plausible pollutant linkage exists.

C1.1.9 For the assessment of construction impacts the baseline Conceptual Site Model (CSM) was revised to include new pollution linkages introduced during the construction phase. The revised CSM was used to establish the risks posed and the potential need for further assessment.

C1.1.10 Assessment of effects in relation to contamination were undertaken in accordance with industry best practice as presented in CLR11. The risk assessment process is underpinned throughout by the development of the CSM, which provides a schematic representation of the identified contaminated linkages.

C1.1.11 The process comprises a tiered approach, which starts with a simple and conservative Tier 1 assessment of potential risks from possible pollutant linkages (Source-Pathway-Receptor). At this stage potential pollutant linkages are identified. Where suitable investigation data

exists to assess these, the data will be used to ascertain whether a risk exists. If suitable investigation data does not exist, the required investigations to confirm whether such a linkage is viable will be defined, e.g. where there is a possibility of presence of made ground, soil sampling and laboratory testing will be identified as the required investigation.

C1.1.12 Any potential risks identified at Tier 1 will be studied in more detail through a Tier 2: Generic Quantitative Risk Assessment (GQRA). The results of any investigations completed will be reviewed at this stage and quantitative assessment is undertaken.

C1.1.13 If a Tier 2 assessment identifies potential risk, i.e. the applied generic assessment criteria are exceeded, a Tier 3: Detailed Quantitative Risk Assessment (DQRA) may be required. This involves derivation of site-specific assessment criteria and may involve additional targeted ground investigations to refine the CSM. Where pollutant linkages are identified as viable on completion of Tier 3 assessments, remediation mitigation measures would be identified. However, the detailed design of how required mitigation would be implemented would be completed at a detailed design stage, including remedial options appraisal and remediation and verification plan.

C1.1.14 It is also acknowledged that, as with any other highway scheme, further investigation work would be carried out and additional assessments completed as construction progresses. These would follow the methodology set out above.

C1.1.15 The assessment is based on all soils that are suitable for reuse being retained on site as part of the proposed scheme. Chemical acceptability criteria will be established for any soils proposed for reuse, with soil samples tested and screened against the acceptability criteria as the work progresses. This would ensure that the acceptability of soils for reuse is demonstrated and verified. Any soils that do not meet the chemical acceptability criteria shall be treated or disposed of to a suitably licenced facility. In addition, a discovery strategy will be developed to enable unforeseen ground conditions to be addressed if or when encountered. Any imported soils will require verification prior to use within the proposed scheme. This approach to soil sampling, testing and assessment will be defined in an earthworks specification for the construction works. This specification will be prepared in accordance with the Specification for Highway Works Series 600 – Earthworks.

Generic quantitative risk assessments methodology – human health

C1.1.16 Where a potential pollution linkage is identified in relation to human health, a Generic Quantitative Risk Assessment (GQRA) will be undertaken on available data. This will be done by screening available soil chemical test results against published generic assessment criteria for a suitable land use scenario, such as DEFRA Category 4 Screening Levels (C4SLs), and where these are not available, the LQM/CIEH Suitable 4 Use Levels (S4ULs). The considered land use scenarios are based on the CSM and will include open public space (park), residential without plant uptake and commercial end-use generic scenarios.

C1.1.17 The applied assessment criteria, as per paragraph above, have been derived using the Environment Agency Contaminated Land Exposure Assessment (CLEA) model. This model defines age classes for receptors within a number of generic end use scenarios.

Generic quantitative risk assessments methodology – controlled waters

C1.1.18 Potential pollution risks to controlled waters have been assessed in accordance with the current Environment Agency's published guidance [32] and the Remedial Targets Methodology [33], and the Water Framework Directive 2000/60/EU as implemented by the 2015 Standards Directions [34].

C1.1.19 Where a potential pollution linkage is identified in relation to controlled waters, a GQRA is undertaken on available data. Where impact of groundwater onto surface waters is being assessed, this is achieved by screening available water chemical testing results against the Environmental Quality Standards for annual average inland surface water (freshwater) values. Impact of hazardous leachable contaminants on the underlying groundwater will be assessed by comparing minimum reporting values against measured concentrations.

C1.1.20 Where the Freshwater Environmental Quality Standards (FEQS) is dependent on bioavailability, which is the case for copper, lead, manganese, nickel and zinc, the Water Framework Directive 'Metal Bioavailability Tool' has been used to correct the ambient concentration for bioavailability; using critical parameters for the assessment at the most sensitive surface water receptor (e.g. calcium

and dissolved organic carbon concentrations). For surface water and leachate, the average pH and calcium values were taken from the surface water samples and a median value of dissolved organic carbon. For groundwater, the bioavailability of metals was calculated per exploratory hole using values sampled within that excavation.

C1.1.21 The FEQS guidance criteria for cadmium varies based on the hardness (as $CaCO_3$) of the assessed controlled water receptor. An average hardness of surface water was used to categorise the criteria for cadmium for the purpose of the controlled waters risk assessment.

Detailed methodology for assessment of potential operational impacts

C1.1.22 Assessment of any new pollution linkages introduced during operation will be discussed and refinements to the baseline conceptual site model will be made.

C1.1.23 The assessment will assume that all soils suitable for reuse would be retained on site for reuse within the scheme. It also assumes that measures to establish acceptable reuse criteria and procedures, to ensure the suitability of material for reuse, can be demonstrated and verified. A discovery strategy would be developed to enable unforeseen ground conditions to be addressed if or when encountered. This approach is in line with the Specification for Highway Works, Series 600 – Earthworks.

Appendix D

Geo-environmental Assessment

D1 Geo-environmental Assessment

Baseline Conceptual Site Model

D1.1.1 The methodology and legislation for deriving the baseline conceptual site model is contained in Appendix C.

D1.1.2 Previous reports including the Supplementary PSSR [3] have not outline a baseline Conceptual Site Model (CSM) for the proposed scheme, rather it refers to the potential sources of contamination and provides a preliminary engineering assessment which discusses contaminated land and soil chemistry.

D1.1.3 Although there are identifiable sources of contamination associated with the baseline scenario (see below), due to the absence of major historical land development and current major contaminative land uses, the proposed scheme is located in an area considered to be of low risk to contamination.

Potential Sources of Contamination (Baseline)

D1.1.4 The potential baseline sources of contamination identified in relation to the proposed scheme alignment are listed in Table D 1 below. Typically, potential sources of contamination within 250m of the proposed alignment have been considered.

Table D 1 Potential sources of contamination

Potential sources	Potential Contaminants
Potential made ground (engineered fill) associated with areas of existing road infrastructure; where the proposed scheme alignment connects / intersects existing road infrastructure (chainages 0+000 to 0+200, 0+580 and 1+779.313).	Metals, hydrocarbons, asbestos, ground gas
Potential areas of previously unidentified made ground along the proposed scheme alignment	Metals, hydrocarbons, asbestos, ground gas
Potential made ground associated with farm access tracks and filling	Metals, hydrocarbons, asbestos, ground gas,
Activities associated with the operation of the existing road network and agricultural activities located within the proposed Scheme alignment and its close proximity. These activities may have resulted in accidental spillages or leakages of fuel; (chainages 0+000 to 0+200, 0+580 and 1+779.313).	Metals, hydrocarbons, pesticides
The former Redstone Forge Garage (now Embroidery Centre) adjacent to the Redstone Cross junction (chainage 0+550)	Metals, asbestos, hydrocarbons
Pollution incident during the ground investigation. This involved a breakage in the hydraulic pump attached to site machinery resulting in 4.5 litres of fuel spillage at chainage 1+320	Aliphatic and aromatic hydrocarbons
Potentially infilled historical watercourse (25m north of the proposed alignment) at chainage 1+060;	Metals, hydrocarbons, asbestos, ground gas
Potentially infilled historical water course (235m north-west of the proposed alignment) at chainage 0+180;	Metals, hydrocarbons, asbestos, ground gas
Potentially infilled land associated with the Rushacre Farm mineral site (220m south of the proposed alignment) and the Green mineral site (200m south of the proposed alignment); nature of infilled material unknown. The Rushacre Farm mineral site is associated wit active opencast quarrying, which is also considered to be a potential source of contamination; hydrocarbon spillages and leaks from plant machinery.	Metals, hydrocarbons, asbestos, ground gas
Farming industry within the vicinity of the Scheme alignment: Redstone Farm (immediately north of the existing A40 alignment) at chainage 0+540; Blackmoor Hill Farm (100m north of the proposed alignment) at chainage 1+230; Pen-blewyn Farm (100m east of the proposed alignment) immediately east of the existing Penblewin roundabout. Blaen-ffynnonau (230m south of the proposed Scheme alignment) at chainage 0+700.	Hydrocarbons, metals, pesticides

D1.1.5 The Supplementary PSSR report [3] identified one potential source of contamination associated with historical land use. This is the inactive Redstone Forge Garage (now Embroidery Centre) which is situated adjacent to the Redstone Cross junction.

D1.1.6 The Supplementary PSSR has since been updated with a revised Annex A [35] document. This document outlines particular areas of investigation that were incorporated into the ground investigation specification. This includes potentially infilled features; i.e. the identified infilled quarries and watercourses. If encountered, these features will be specified for the appropriate geo-environmental testing and assessed accordingly. Based on the findings of the ground investigation, it has been concluded that no infilled features have been identified.

D1.1.7 The findings of the A40 Redstone Cross to Penblewin ground investigation indicated that no made ground materials were encountered across the proposed scheme alignment. This is likely to be attributed to the fact that the locations of the exploratory holes were placed in areas of previously undeveloped land. Potential made ground associated with the road construction ('engineered fill') is unlikely to pose a contamination risk; as this is likely to consist of clean import materials. Potential made ground associated with uncontrolled agricultural practices, such as filling/farming land access tracks are likely to pose a greater risk of potential contamination.

D1.1.8 Based on the historical land development summary provided in Section 3.3, agricultural land practices and activities associated with the operational procedures of the existing road alignment (i.e. fuel spillages from vehicles on roads and tractors in fields) are also considered to be a plausible source of contamination. However, these are anticipated to be very localised with minimal adverse impact on land contamination.

D1.1.9 Potentially infilled watercourses have been identified within the vicinity of the scheme. Additionally, Rushacre Farm mineral site and the Green mineral site are both located within 250m of the scheme and are associated with infilled features; dating to 1974. The nature of the infilled watercourses and the infilled land associated with the mineral sites is currently unknown. Given the distance from the proposed alignment, it is considered unlikely that these features will be encountered during construction. However, there is a residual risk associated with previously unidentified infilled features during construction.

D1.1.10 A pollution incident occurred during the ground investigation, which resulted in the spillage of 4.5 litres of 'Type 46 mineral hydraulic oil' into the surrounding groundwater. This will be discussed further in the assessment.

Potential Receptors (Baseline)

D1.1.11 The potential receptors of any contamination that may exist along the proposed scheme are listed in this section. The potential receptors have been separated into human and environmental receptors; as these are discussed separately in the human health and controlled waters risk assessments. The receptors are listed below:

Human receptors:

Residents and workers of the farms and adjacent housing within the vicinity of the scheme. These include:

D1.1.12 Residents and workers within the Blaenmarlais Care Home facility 20m south of the scheme at chainage 0+600. This also includes the surrounding residential dwellings along the B4313.

D1.1.13 Residents and workers of the Blackmoor Hill Farm immediately south of the existing A40 alignment, approximately 110m north of the proposed scheme at chainage 1+220.

D1.1.14 Residents of Jacob's Park immediately west of the proposed alignment (100m south).

D1.1.15 Residents and workers of Blaen-ffynnonau Farm (230m south of the proposed scheme alignment) at chainage 0+700.

D1.1.16 Residents and workers of Redstone Farm immediately north of the existing Redstone Cross junction.

D1.1.17 The residential property and the Embroidery Centre along the southern periphery of the existing A40 alignment, adjacent to the Redstone Cross junction.

a) Users of agricultural land.
b) Maintenance workers of the existing A40 and B4313 road(s).
c) Users of the existing connecting B4313 road(s), including motorised and non-motorised users (such as cyclists, pedestrians, horse riders, etc).

Environmental receptors:

a) Two tributaries of the Afon Marlais watercourse: chainage(s) 0+800 (approximately 55m south) and 1+220 (intersects the proposed alignment).

b) Tributary of the Narberth Brook at chainage 0+400 (intersects the proposed scheme alignment to the south-west of Redstone Cross Junction.

c) A well, numerous ponds and the unnamed tributaries of Longford Brook; as discussed in Section 4.

d) The Llandeilo Flags Formation; Secondary A aquifer.

Potential Pathways (Baseline)

D1.1.18 The pathways of potential contamination are summarised in this section. These has been distinguished into pathways to human health and pathways to controlled waters.

D1.1.19 In summary, the main pathways associated with exposure to human receptors are ingestion of soils and dust, inhalation of dusts (as well as gases and volatile hydrocarbon contamination) and dermal contact with contaminated soils. The main pathways that may impact controlled waters is associated with leachate generation from made ground and vertical/lateral migration of contamination impacting the identified controlled waters receptors.

D1.1.20 The pathways are listed below.

Pathways to Human Health:

a) Ingestion of soils and dust.

b) Inhalation of dust, gases and volatile hydrocarbon contamination.

c) Dermal contact with soils, dust and groundwater.

d) Gas migration from made ground into near surface.

D1.1.21 As regular maintenance works typically do not involve deep excavations, no direct exposure to groundwater or ground gas/vapours is likely to occur.

D1.1.22 Risk of exposure to ground gas is considered to be low, as no elevated levels of ground gas were measured during the ground investigations.

Pathways to Controlled Waters:

D1.1.23 Vertical and lateral migration of contaminants released to the ground from spillage or leaks; i.e. hydrocarbons spills from vehicles along the existing A40 alignment which may vertically/laterally migrate and impact groundwater or surface waters;

D1.1.24 Leachate generation and migration from areas of potential made ground along the existing alignment; and

D1.1.25 Leaching of contaminants into the underlying groundwater resulting in contamination. The groundwater may flow towards surface water features; potentially impacting surface water and / or groundwater quality.

Plausible Pollution Linkages

D1.1.26 The plausible pollutant linkages have been summarised in Table D 2 below.

Table D 2 - Plausible Pollution Linkages

Sources	Pathways	Receptors	Comments
Made ground associated with: Existing road network (likely engineered fill) Agricultural activities localised to e.g. access tracks, infilled land Leaks and spillages (e.g. fuels and chemicals) from operation of the existing road network and agricultural activities (primarily areas of farms and storage). Redstone Forge Garage Pollution incident during GI (BH9) Infilled quarries/ watercourses, agricultural activities	Exposure to soil dust via ingestion, dermal contact and inhalation Limited exposure to soils via ingestion, dermal contact and inhalation (only during intrusive maintenance works) Inhalation of vapours and ground gases	<u>Human health:</u> Scheme neighbours - residents and workers of the farms Existing A40 maintenance workers and users Agricultural land users (workers)	Maintenance workers and highway users may be directly exposed to soil and dust generated from areas of made ground along the highway (engineered fill). This is considered to be relatively low risk of contamination. Users of the existing A40 and surrounding agricultural land are unlikely to be significantly impacted by contamination due to short term exposure only.
	Leaching and migration Surface run-off	<u>Controlled waters</u>: Surface water features (streams; springs and ponds) Groundwater	Potential contaminants within the identified sources may leach to groundwater and via lateral migration have potential to impact the surface waters quality.

Construction Phase

D1.1.27 The construction phase of the proposed scheme may introduce additional sources, pathways and receptors to the initial baseline conditions.

Potential Sources Introduced during Construction

D1.1.28 During construction, it is possible that the following additional sources of contamination may be introduced as a result of construction activities:

a) Areas of unexpected contamination (i.e. previously unencountered made ground) that may be encountered and excavated as a result of the construction works.

b) Imported and site won construction materials e.g. for the construction of the earth embankments. However, the reuse of site won or imported materials will be carried out in line with Specification for Highways Earthworks Series 600. Therefore, only materials considered suitable for reuse will be used during the proposed works. Therefore, these materials are not considered to be a potential source of contamination.

Potential Receptors Introduced during Construction

D1.1.29 The construction works would potentially introduce the following additional receptors:

a) Construction workers: It has been assumed that the construction workers include adults and also apprentices aged 16 and above.

Potential Pathways Introduced during Construction

D1.1.30 The construction works would potentially introduce the following additional pathways:

a) Direct discharge of groundwater removed from ground as a result of dewatering operations.

b) Direct exposure to soils/dust or groundwater (such as dermal contact, ingestion and / or the inhalation of vapours) during excavation works.

Operational Phase

D1.1.31 Post completion of the proposed scheme alignment, there is the potential for new sources, pathways and receptors to be introduced.

Potential Sources Introduced during Operation

D1.1.32 No additional sources of contamination are anticipated to be introduced during the operational phase of the proposed scheme.

Potential Receptors Introduced during Operation

D1.1.33 The operational phase of the scheme would potentially introduce the following additional receptors:

D1.1.34 New A40 maintenance workers.

Potential Pathways Introduced during Operation

D1.1.35 No additional pathways of contamination are anticipated to be introduced during the operational phase of the proposed scheme.

Human Health Risk Assessment

Methodology and Averaging Areas

D1.1.36 The samples collected from the ground investigation have collected 17no. samples of natural strata. No made ground was encountered.

D1.1.37 The results of the chemical analyses have been used to assess the risks posed to human health, as well as to inform the chemical suitability for material reuse along the proposed scheme.

D1.1.38 For a comprehensive overview of the detailed methodology, see Appendix C; which predominantly follows the Environment Agency 'CLEA' framework [36] .

D1.1.39 If the results from an adequate site investigation are below the scientific and appropriate guidelines, then the site can be regarded as uncontaminated and as suitable for the proposed end-use, subsequently allowing development to proceed (subject to there being no risk to the water environment). If the results exceed the screening guidelines, then more detailed risk assessment is required to ascertain whether there is a need for remediation.

D1.1.40 The proposed scheme alignment traverses north-east to south-west across areas of predominantly land that has not previously been developed; chainages 0+200 to 0+500 and chainages 0+600 to 1+700. However, there are a number of residential dwellings within the vicinity of the alignment, illustrating that there are multiple end uses surrounding the area of the proposed scheme alignment.

D1.1.41 In order to assess the risks posed to human health during construction, in the absence of acute-term exposure GACs, soil dry weight samples have been screened against the most stringent end use criteria - residential no plant uptake. Additionally, to assess the risks posed to end users, soil samples obtained from the site have been screened against residential no plant uptake, public open space (park) and commercial screening criteria; to account for these land uses along the scheme.

D1.1.42 Exceedances in the applied screening criteria will provide an indication in the nature of the risks posed to construction workers and site end users.

Assessment Criteria

D1.1.43 The assessment criteria used are outlined in Appendix C. This includes the Defra 'Category 4 Screening Levels' [37] and the Land Quality Management 'Suitable 4 Use Levels'; as described in the 'Environment Agency's SR2 guidance' [38].

Tier 1 Risk Assessment

D1.1.44 The results of the soil dry weight analyses showed no exceedances in relation to the applied screening criteria. Additionally, the lithological logs from the ground investigation do not suggest any visual or olfactory evidence of contamination.

D1.1.45 Although there remains a risk of encountering made ground associated with the existing alignment of the A40, it is considered that the risk posed to human health is low.

D1.1.46 Based on the chemical results of the encountered samples, there is no risk posed to human health during construction and operation. Additionally, from the assessment it is considered that the encountered materials are considered suitable for reuse with respect to human health.

Controlled Waters Risk Assessment

D1.1.47 The detailed controlled waters risk assessment methodology is contained in Appendix C.

D1.1.48 The identified controlled waters receptors include the groundwater contained within the bedrock (i.e. the Secondary A aquifer - Llandeilo Flags Formation), as well as numerous surface water features;

including tributaries of the Afon Marlais, Narberth Brook and several ponds.

D1.1.49 In accordance with the guidance referred to in Appendix C, the available groundwater, surface water and leachate results have been screened against the Environmental Quality Standards (EQS) for freshwater. In the absence of water abstraction licenses (within 1km of the proposed scheme), the results have not been screened against the UK Drinking Water Standards.

Evidence of Contamination

D1.1.50 No evidence of soil contamination was encountered during the investigatory works. With respect to hydrocarbon concentrations in the soil, Total Petroleum Hydrocarbons and Speciated PAHs were measured below the limit of laboratory detection; with the exception of BH09 in the second round of groundwater sampling; as discussed in the baseline CSM.

Soil Leachate

D1.1.51 8no. samples of natural strata were obtained from exploratory holes along the proposed scheme and were subject to leachate analyses; which comprise the basis of the soil quality assessment.

D1.1.52 The review of the results indicated an exceedance in the applied screening criteria in relation to cadmium; in RCEBH13 (0.00086mg/l). The remaining concentrations of leachable cadmium are below the laboratory limit of detection which is above the applied screening criteria of 0.00008mg/l.

D1.1.53 From the findings of the assessment, there was one exceedance in bioavailable copper (RCE-TP11); 0.0013mg/l. The methodology for correcting for bioavailability is in Appendix C.

Groundwater Quality Assessment

D1.1.54 Three rounds of groundwater sampling have been undertaken as part of the 2019 ground investigation. The results were subsequently screened against Freshwater EQS criteria, with any exceedances reported in Table D 3 below.

Table D 3 Exceedances in the applied Freshwater EQS (2015) – assessment criteria to determine groundwater quality.

Determinand	Exploratory hole and monitored strata	Measured Concentration (Exceedance in F-EQS)	F-EQS Criteria
Cyanide	BH01 - Round 1 (Haverford Beds, Gasworks Sandstone)	0.31 mg/l	0.001 mg/l
Aromatic TPH >C21-C35	BH09 - Round 2 (Dicranograptus Beds)	1100 µg/l (Total measured TPHs is 5100ug/l)	90 µg/l
Cadmium	BH02 - Round 1 (Slade and Redhill Formation)	0.11µg/l	0.09 µg/l (Class 3 hardness based on the Water Framework Directive classification)
	BH05 - Round 1 (Dicranograptus Beds)	0.14µg/l	
	BH08 - Round 1 (Dicranograptus Beds)	0.095µg/l	
	BH14 - Round 1 (Slade and Redhill Formation)	0.17µg/l	
	BH15 - Round 1 (Slade and Redhill Formation)	0.11µg/l	
	BH16 - Round 1 (Slade and Redhill Formation)	0.096µg/l	
	BH1 - Round 3 (Haverford Beds, Gasworks Sandstone)	0.3µg/l	
	BH10 - Round 3 (Slade and Redhill Formation)	0.32µg/l	
Mercury	BH05 - Round 2 (Dicranograptus Beds)	0.6µg/l	0.07 µg/l
	BH13 - Round 2 (Slade and Redhill Formation)	1.1µg/l	
Bioavailable Zinc	BH02 - Round 1 (Slade and Redhill Formation)	17.38 µg/l	12.9 µg/l (10.9 µg/l background concentration + 2 µg/l River Tywi catchment)
	BH07 - Round 1 (Dicranograptus Beds)	12.97 µg/l	
	BH08 - Round 1 (Dicranograptus Beds)	98.49 µg/l	
	BH10 - Round 1 (Slade and Redhill Formation)	24 µg/l	

Determinand	Exploratory hole and monitored strata	Measured Concentration (Exceedance in F-EQS)	F-EQS Criteria
	BH12 - Round 1 (Slade and Redhill Formation)	15.61 µg/l	
	BH13 - Round 1 (Slade and Redhill Formation)	21.63 µg/l	
	BH14 - Round 1 (Slade and Redhill Formation)	14.37 µg/l	
	BH02 - Round 2 (Slade and Redhill Formation)	16.2 µg/l	
	BH03 - Round 3 (Slade and Redhill Formation)	17.47 µg/l	
	BH08 - Round 3 (Dicranograptus Beds)	15.43 µg/l	
	BH13 - Round 3 (Slade and Redhill Formation)	15.97 µg/l	
	BH14 - Round 3 (Slade and Redhill Formation)	14.8 µg/l	
	BH16 - Round 3 (Slade and Redhill Formation)	17.12 µg/l	

D1.1.55 As documented in Table D 3, a number of exceedances have been identified from the sampled groundwater. Based on the interpretation of the hydrogeology, it is likely that the encountered groundwater reflects one continuous groundwater body.

D1.1.56 Table D 3 shows 8no. exceedances in the applied F-EQS for cadmium (based on a Class 3 hardness). The elevated concentrations of cadmium are distributed across the proposed scheme, with 6no exceedances in Round 1 and 2no exceedances in Round 3. Cadmium was measured below the laboratory limit of detection in all of the sampled groundwater in Round 2.

D1.1.57 Upon review of the potential sources of contamination, there is no definitive potential source of contamination which can be related to the site wide elevated concentrations of cadmium in sampled groundwater.

D1.1.58 Table D 3 shows 1no exceedance in the applied F-EQS for cyanide. This was measured in Round 1 of groundwater sampling in BH01; at a concentration of 0.31mg/l. All of the remaining sampled groundwater

across the scheme shows cyanide concentrations below the laboratory limit of detection. There are no explicit potential sources of contamination that are likely to be attributed to the elevated cyanide encountered in BH01.

D1.1.59 Table D 3 shows 2no exceedances in the applied F-EQS for mercury. Both of these exceedances were measured in Round 2 of groundwater sampling, with the remaining rounds registering mercury concentrations below detection. There are no plausible potential sources of contamination attributed to the 2no mercury exceedances.

D1.1.60 Table D 3 shows 13no exceedances in the applied bioavailable zinc F-EQS. The majority of these exceedances are restricted to Round 1 and Round 3 of groundwater sampling; with 1no exceedance measured in Round 2. The exceedances are documented across the proposed scheme, with no definite contamination source identified.

D1.1.61 From the findings of the assessment, the elevated concentrations of Total Petroleum Hydrocarbons are recorded in Round 2 of groundwater sampling (in groundwater within BH09). TPHs in this sample are recorded at a concentration of 5,100ug/l. In the absence of identifiable sources within the vicinity of BH09, it is considered likely that the recorded concentrations of TPHs are on account of the pollution incident that occurred during the ground investigation; which resulted in the spillage of 4.5 litres of 'Type 46 mineral hydraulic oil'. It is likely that the pollution incident will not result in significant and widespread contamination, however recommendations pertaining to verification measures are discussed below.

D1.1.62 The exceedances in the applied F-EQS criteria concerning cadmium, cyanide, mercury and bioavailable zinc do not appear to be associated with a definite source of potential contamination; in the context of the study area. It is possible that the exceedances in the F-EQS may be influenced by potential sources of contamination located outside of the study area. Conversely, these concentrations may represent the local background concentrations of groundwater in the area.

Surface Water Quality Risk Assessment

D1.1.63 Three rounds of surface water sampling were undertaken as part of the 2019 ground investigations; from 4no locations as shown on Figures 3 and 4. The samples correspond to the following watercourse: Two samples were taken from the tributary of the Narberth Brook; one

sample was taken from a small drain and the last sample was taken from the tributary of the Afon Marlais; see Figures 3 and 4.

D1.1.64 The surface water sampling indicated that the majority of the measured determinands are registered below the limit of detection; including Total Petroleum Hydrocarbons and speciated PAHs.

D1.1.65 The assessment indicated 1no exceedance in the applied F-EQS, pertaining to cadmium measured at SW1 from Round 2 of surface water sampling (75 µg/l); significantly exceeding the F-EQS criteria of 0.09 µg/l. At the same sampling location, cadmium was measured below the limit of detection in both Round 1 and Round 3 of surface water sampling.

D1.1.66 Upon review of the potential sources of contamination in the scope of the study area, there are no definite sources of potential cadmium. Additionally, although the groundwater and soil quality (leachate) assessments indicated elevated cadmium concentrations, the exceedance in surface water is significantly higher than the measured groundwater and leachate concentrations. This suggests that the elevated cadmium measured in surface water is not due to impact from groundwater or leaching of the soil.

Materials Management

Suitability for Reuse

D1.1.67 The findings of the Tier 1 human health risk assessment concluded that the encountered material to date is considered chemically suitable for reuse relative to the proposed site end uses along the proposed alignment. This is because there were no exceedances in the applied screening criteria and all encountered materials comprised of natural strata.

D1.1.68 The results of the soil quality assessment (leachate) indicated 2no exceedances in the F-EQS criteria; see assessment above. The exceedances do not correspond to any definitive source of potential contamination and were sampled in natural strata. All of the encountered material during the ground investigation comprised of natural materials.

D1.1.69 On this basis, the encountered materials subject to the Tier 1 assessment are considered to be suitable for reuse along the proposed scheme. Should any made ground or materials previously

unencountered be identified, the appropriate testing to confirm the suitability for reuse should be undertaken. Materials encountered during construction that display visual or olfactory evidence of contamination are not considered to be suitable for reuse along the scheme.

Disposal Options

Material Off-Site Disposal

D1.1.70 Based on current proposals, it is understood that materials arising from the excavation works are to be re-used within the scheme. However, any surplus or unsuitable materials may require off-site disposal.

D1.1.71 Materials subject to off-site disposal should undergo the appropriate dry weight and WAC testing, which will allow for characterisation of waste and identification of potential off-site disposal options in accordance with current waste management guidance. The testing requirement may vary depending on disposal option. It is recommended that disposal at landfill is considered as a last resort with reuse/recycling considered first.

D1.1.72 Based on the ground conditions encountered to date, the majority of the surplus materials are likely to comprise primarily natural soils. In accordance with current waste management guidance, these materials are likely to be suitable for inert landfill disposal without testing. Disposal at soil recycling or waste transfer stations may attract different testing requirements.

D1.1.73 The completed investigatory works to date did not encounter made ground or visual/olfactory evidence of contamination in the soil. Made ground and/or materials exhibiting evidence of hydrocarbon contamination may require disposal at non-hazardous or hazardous waste facilities subject to suitable assessments.

Water Management

D1.1.74 Should dewatering works be required during construction, consideration should be given to the abstraction and subsequent discharge of groundwater. Water impacted by contamination will require treatment prior to discharge. Discharge licence may be required.

Health and Safety Provisions during Construction

D1.1.75 Based upon the findings of the human health risk assessment, there are no exceedances of the applied screening criteria applied with respect to potential risks posed to construction and maintenance workers. Therefore, the scheme is unlikely to pose a risk to site personnel during construction and maintenance works.

D1.1.76 There is however the potential for previously unencountered made ground to be identified during the construction works. The health and safety systems applied during the construction works should consider the potential for encountering previously unencountered materials that may be impacted by contamination. Contingency plan should be derived setting out procedures to deal with unexpected contamination.

D1.1.77 With respect to the pollution incident that occurred during the ground investigation (BH09). Groundwater testing has identified elevated levels of Total Petroleum Hydrocarbons. Should construction work encounter groundwater in that location, appropriate health and safety measures may be a requirement in that location.

Remediation Requirements

D1.1.78 The completed risk assessments have not identified the presence of significant contamination or potential sources of significant contamination. There is the potential for localised areas of unexpected contamination that may be encountered during construction.

D1.1.79 The pollution incident that occurred during the ground investigation in BH09 has resulted in elevated concentrations of Total Petroleum Hydrocarbons in groundwater (5100ug/l TPHs). The review of the available desk study information has not identified any plausible sources of hydrocarbons in the vicinity and therefore it is likely that this is the result of the incident. Considering the available information with respect to the pollution incident, it is unlikely to have resulted in significant and widespread contamination not requiring remediation. However, to confirm if any impacts on groundwater still persist, it is recommended to undertake further sampling and testing of groundwater. This could be undertaken during construction of the scheme.

D1.1.80 Additionally, from evidence provided by the contractor, it is not clear whether any spillage on the surrounding soils has occurred. It is therefore recommended that soils in the vicinity of BH09 are also

sampled and tested to confirm that the source of hydrocarbons has been removed.

D1.1.81 Should land contamination remediation work be necessary, the requirements will be set out in a Remediation Strategy developed for the scheme.

Lab Sample ID						885654	886769	886816	888873	888914	888916	888917
Depth (m)						0.30	0.3	1.0	0.3	0.7	1.0	0.3
Date Sampled						05-Sep-2019	06-Sep-2019	09-Sep-2019	11-Sep-2019	10-Sep-2019	10-Sep-2019	10-Sep-2019
GI Name						RCEBH13	RCEBH14	RCEBH04	RCEBH07	RCE-TP19	RCE-TP05	RCE-BH06
Strata Description	**Assessment Criteria**	**Residential C4SLs/S4ULs/ Arup GAC (1% OC) no plant uptake**	**Public Open Space C4SLs/S4ULs/ Arup GAC (1% OC)**	**Commercial C4SLs/S4ULs/ Arup GAC (1% OC)**		**TOPSOIL:** Brown slightly silty slightly gravelly CLAY.	**NG:** Grey brown silty clayey slightly sandy GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone (Weathered mudstone).	**NG:** Mudstone rock, recovered as: Grey brown slightly clayey GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone.	**NG:** Pale brown slightly sandy slightly gravelly CLAY.	**NG:** Grey brown clayey slightly silty slightly sandy GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone (weathered mudstone rock).	**NG:** Grey brown slightly clayey slightly silty slightly sandy GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone. (Weathered mudstone rock).	**NG:** Pale brown slighty sandy slightly gravelly CLAY.
Analytical Parameter (Soil Analysis)					Units							
Moisture Content					%	7.0	11	5.6	20	8.7	9.4	19
General Inorganics												
pH					pH Units	8.1	7.4	7.7	6.3	7.8	7.8	7.1
Total Cyanide	Arup GAC 2018 (1%)	800	3460	16200	mg/kg	< 0.50	< 0.50	< 0.50	8.1	< 0.50	< 0.50	< 0.50
Total Organic Carbon					%	0.26	0.53	< 0.20	0.81	0.25	0.23	0.74
Total Phenols												
Total Phenols					mg/kg	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
Speciated PAHs												
Naphthalene	(LQM S4UL - 1% SOM)	2.3	1200 (76.4)	190 (76.4)	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthylene	(LQM S4UL - 1% SOM)	2900	29000	83000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Acenaphthene	(LQM S4UL - 1% SOM)	3000	29000	84000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluorene	(LQM S4UL - 1% SOM)	2800 (30.9)	20000	63000 (30.9)	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Phenanthrene	(LQM S4UL - 1% SOM)	1300 (36.0)	6200	22000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Anthracene	(LQM S4UL - 1% SOM)	31000 (1.17)	150000	520000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Fluoranthene	(LQM S4UL - 1% SOM)	1500	6300	23000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Pyrene	(LQM S4UL - 1% SOM)	3700	15000	54000	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(a)anthracene	(LQM S4UL - 1% SOM)	11	49	170	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chrysene	(LQM S4UL - 1% SOM)	30	93	350	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(b)fluoranthene	(LQM S4UL - 1% SOM)	3.9	13	44	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(k)fluoranthene	(LQM S4UL - 1% SOM)	110	370	1200	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(a)pyrene	(C4SL- 6% SOM)	5.3	21	77	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Indeno(1,2,3-cd)pyrene	(LQM S4UL - 1% SOM)	45	150	500	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Dibenz(a,h)anthracene	(LQM S4UL - 1% SOM)	0.31	1.1	3.5	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Benzo(ghi)perylene	(LQM S4UL - 1% SOM)	360	1400	3900	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total PAH												
Speciated Total EPA-16 PAHs					mg/kg	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Heavy Metals / Metalloids												
Arsenic (aqua regia extractable)	(C4SL- 6%)	40	170	640	mg/kg	9.6	8.9	12	12	12	8.2	8.1
Boron (water soluble)	(LQM S4UL- 6%)	11000		240000	mg/kg	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	0.42
Cadmium	(C4SL- 6%)	150	880	410	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Chromium (hexavalent)	(C4SL- 6%)	21	250	33	mg/kg	< 0.50		< 0.50			< 0.50	
Chromium	(LQM S4UL - 6%)	910	33000	8600	mg/kg	22	14	20	27	18	22	17
Copper (aqua regia extractable)	(LQM S4UL - 6%)	7100	44000	68000	mg/kg	16	9.6	13	15	15	25	6.2
Lead (aqua regia extractable)	(C4SL- 6%)	310	1300	2300	mg/kg	12	12	14	14	41	22	14
Mercury (aqua regia extractable)	(LQM S4UL - 6%)	1.2	30 (25.8)	58	mg/kg	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Nickel (aqua regia extractable)	(LQM S4UL - 6%)	180	3400	980	mg/kg	33	24	28	27	36	42	13
Selenium (aqua regia extractable)	(LQM S4UL - 6%)	430	1800	12000	mg/kg	< 0.20	0.47	< 0.20	1.0	< 0.20	< 0.20	1.3
Zinc (aqua regia extractable)	(LQM S4UL - 6%)	40000	170000	730000	mg/kg	64	55	63	50	81	110	27
Monoaromatics & Oxygenates												
Benzene	(C4SL- 6% SOM)	3300	230000	98000	ug/kg		< 1.0			< 1.0		< 1.0
Toluene	(LQM S4UL - 1% SOM)	880000	87000000	56000000	µg/kg		< 1.0			< 1.0		< 1.0
Ethylbenzene	(LQM S4UL - 1% SOM)	83000	17000000	5700000	µg/kg		< 1.0			< 1.0		< 1.0
p & m-xylene	(LQM S4UL - 1% SOM)	79000		5900000	µg/kg		< 1.0			< 1.0		< 1.0
o-xylene	(LQM S4UL - 1% SOM)	88000	17000000 (478000)	6600000	µg/kg		< 1.0			< 1.0		< 1.0
Petroleum Hydrocarbons												
Total TPH >C6-C40					mg/kg	<10		< 10	< 10		< 10	
Total Petroleum Hydrocarbons					mg/kg		< 10			< 10		< 10
TPH-CWG - Aliphatic >EC5 - EC6	(LQM S4UL - 1% SOM)	42	95000 (304)	3200 (304)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC6 - EC8	(LQM S4UL - 1% SOM)	100	150000 (144)	7800 (144)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC8 - EC10	(LQM S4UL - 1% SOM)	27	14000 (78)	2000 (78)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC10 - EC12	(LQM S4UL - 1% SOM)	130 (48)	21000 (48)	9700 (48)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	(LQM S4UL - 1% SOM)	1100 (24)	25000 (24)	59000 (24)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC16 - EC21	(LQM S4UL - 1% SOM)	65000 (8.48)	450000	1600000	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC21 - EC35	(LQM S4UL - 1% SOM)	65000 (8.48)	450000	1600000	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aliphatic >EC35-EC44	(LQM S4UL - 1% SOM)	65000 (8.48)	450000	1600000	mg/kg		< 1.0			< 1.0		< 1.0
Total Aliphatic Hydrocarbons					mg/kg		< 5.0			< 5.0		< 5.0
					mg/kg							
TPH-CWG - Aromatic >EC5 - EC7	(LQM S4UL - 1% SOM)	370	76000 (1220)	26000 (1220)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC7 - EC8	(LQM S4UL - 1% SOM)	860	87000 (869)	56000 (869)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC8 - EC10	(LQM S4UL - 1% SOM)	47	7200 (613)	3500 (613)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC10 - EC12	(LQM S4UL - 1% SOM)	250	9200 (364)	3800	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC12 - EC16	(LQM S4UL - 1% SOM)	1800	10000	36000 (169)	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC16 - EC21	(LQM S4UL - 1% SOM)	1900	7600	28000	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC21 - EC35	(LQM S4UL - 1% SOM)	1900	7800	28000	mg/kg		< 1.0			< 1.0		< 1.0
TPH-CWG - Aromatic >EC35-EC44	(LQM S4UL - 1% SOM)	1900	7800	28000	mg/kg		< 1.0			< 1.0		< 1.0
Total Aromatic Hydrocarbons					mg/kg		< 5.0			< 5.0		< 5.0
					mg/kg							

890337	892840	892841	892846	892848	893282	895568	895569	897990	897993	897901	897902	899911	899913	906004	906007	906010
0.30	1.00	0.30	0.30	0.30	0.30	1.00	0.30	1.0	0.3	1.0	0.3	0.30	0.30	0.30	1.00	0.30
13-Sep-2019	17-Sep-2019	18-Sep-2019	18-Sep-2019	17-Sep-2019	19-Sep-2019	20-Sep-2019	23-Sep-2019			26-Sep-2019	26-Sep-2019	02-Oct-2019	02-Oct-2019			
RCE-BH5	RCE-BH01	RCE-BH02	RCE-TP11	RCE-BH01	RCEBH08	RCETP02	RCETP03	RCETP06	RCETP07	RCETP15	RCETP13	RCETP10	RCETP09	RCE-TP03	RCE-TP04	RCE-TP06
NG: Light brown slightly sandy slightly gravelly CLAY with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse. Cobbles are subangular to subrounded of sandstone.	**NG:** Strong light grey/light brown fractured SANDSTONE.	**NG:** Grey brown clayey sandy GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone.	**NG:** Pale mottled orange grey brown slightly sandy slightly gravelly CLAY. Gravel is angular to sub-angular fine to coarse mudstone and sandstone.	**NG:** Light brown clayey GRAVEL with low cobble content. Gravel is angular to sub-angular fine to coarse sandstone. Cobbles are sub-angular sandstone (probable weathered bedrock).	**NG:** Stiff light brown slightly sandy slightly gravelly CLAY with low cobble conent. Sand is fine to coarse. Gravel is sub-rounded fine to coarse. Cobbles are subangular to subrounded of sandstone.	**NG:** Pale brown slightly clayey sandy GRAVEL with low to medium cobble content of calcareous sandstone. Gravel is angular to sub-angular fine to coarse calcareous sandstone.	**TOPSOIL:** Turf over topsoil. Brown slightly sandy slightly gravelly CLAY.	**NG:** Pale brown clayey slightly sandy GRAVEL. Gravel is angular to sub-angular fine to coarse mudstone.	**NG:** Orange brown gravelly sandy CLAY with many rootlets.	**NG**: Gravel	**NG**: Gravel	**NG:** Organic clay topsoil	**NG:** Pale orange brown slightly gravelly clay.	**NG:** Brown slightly sandy slightly gravelly clay	**NG**: Brown slightly sandy clayey gravel	**NG**: Pale brown slightly sandy gravel.
15	16	11	27	25	26	9.0	22	7.1	18	11	8.6	21	16	14	8.8	16
7.4	7.2	7.0	5.6	6.2	5.5	7.8	7.0	[A] 7.3	[A] 6.5	[B] 6.8	[B] 6.3	5.3	7.3	[A] 6.2	[A] 7.6	[A] 6.3
< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	[A] < 0.50	[A] < 0.50	[B] < 0.50	[B] < 0.50	< 0.50	< 0.50	[A] 0.90	[A] < 0.50	[A] < 0.50
0.60	0.30	0.21	< 0.20	1.1	1.3	< 0.20	3.4	[A] 0.28	[A] 1.3	[B] 0.90	[B] 2.1	6.1	0.45	[A] 0.52	[A] 0.40	[A] 0.37
< 0.30					< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30	< 0.30
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 2.0	<2.0	<2.0	<2.0	<2.0	< 2.0	< 2.0		< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
9.9	15	9.5	19	16	9.0	11	11	15	13	18	15	6.9	11	19	14	8.0
0.68	0.50	< 0.40	< 0.40	0.52	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	< 0.40	0.58	0.41	< 0.40	3.4	1.7
< 0.10	< 0.10	< 0.10	< 0.10	0.16	< 0.10	< 0.10	0.18	< 0.10	< 0.10	< 0.10	0.12	0.11	0.13	< 0.10	< 0.10	< 0.10
21	23	16	18	15	21	6.1	10	24	23	27	22	8.5	21	20	25	26
15	23	24	7.7	13	5.3	4.5	9.1	14	10	16	10	5.4	14	18	28	16
15	47	15	11	23	19	10	21	15	22	21	27	11	30	17	16	19
< 0.10	0.15	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
21	14	30	15	8.7	20	2.1	5.3	32	22	31	19	7.4	21	41	34	28
0.61	0.76	0.25	0.43	0.55	0.24	< 0.20	0.37	< 0.20	0.72	0.40	0.67	0.95	0.74	0.36	0.26	< 0.20
65	110	81	27	36	29	3.9	23	74	59	68	45	12	51	62	73	58
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] 1.5		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
< 10	< 10				< 10			[A] < 10		[B] < 10				[A] < 10	[A] < 10	
		< 10	< 10	< 10		< 10	< 10		[A] < 10		[B] < 10	< 10	< 10	[A] < 10		[A] < 10
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 5.0	< 5.0	< 5.0		< 5.0	< 5.0		[A] < 5.0		[B] < 5.0	< 5.0	< 5.0	[A] < 5.0		[A] < 5.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		[A] < 1.0		[B] < 1.0	< 1.0	< 1.0	[A] < 1.0		[A] < 1.0
		< 5.0	< 5.0	< 5.0		< 5.0	< 5.0		[A] < 5.0		[B] < 5.0	< 5.0	< 5.0	[A] < 5.0		[A] < 5.0

Lab Sample ID	Surface Water Freshwater EQS (2015) [FEQS]		886769	887870	887874	888873	888914	888917	892846	893985	888918	906004
GI Name			RCEBH14	RCEBH13	RCEBH04	RCEBH07	RCE-TP19	RCE-BH06	RCE-TP11	RCE-BH01	RCE- TP05	RCE-TP03
Depth (m)			0.3	0.30	1	0.3	0.7	0.3	0.30	0.3	1	0.30
Date Sampled			06-Sep-2019	05-Sep-2019	09-Sep-2019	11/09/2019	10-Sep-2019	10-Sep-2019	18/09/2019	-	10/09/2019	
Analytical Parameter (Leachate Analysis)		**Units**										
General Inorganics												
pH	nc	pH Units	4.6	7.7	7.6	8.9	7.9	7.8	8.4	7.2	7.7	8.7
Total Cyanide	0.001	mg/l	<0.050			<0.050	< 0.050	< 0.050	< 0.050			< 0.050
Ammoniacal Nitrogen	nc	mg/l	0.21			0.065	0.13	0.051	0.16			0.54
Total Phenols												
Total Phenols	nc	mg/l	< 0.30									
Heavy Metals / Metalloids												
Antimony (dissolved)	nc	mg/l		< 0.0010	0.0019					0.0011	< 0.0010	
Arsenic (dissolved)	0.05	mg/l	< 0.0010	0.0028	< 0.0010	< 0.0010	0.0018	< 0.0010	0.0052	0.0015	< 0.0010	0.0050
Barium (dissolved)	nc	mg/l	0.0033	0.0034	0.0083	0.0013	0.0033	0.0036	0.0035	0.0023	0.0025	0.0030
Beryllium (dissolved)	nc	mg/l										
Boron (dissolved)	nc	mg/l										
Cadmium (dissolved)	0.00008	mg/l	< 0.00010	0.00086	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chromium (hexavalent)	0.0034	mg/l										
Chromium (III)	0.0047	mg/l										
Chromium (dissolved)	nc	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0037	< 0.0010	< 0.0010	0.038
Copper (dissolved)	nc	mg/l	0.0021	0.0017	0.0017	< 0.0010	0.0023	0.0010	0.047	0.0023	0.0016	0.0084
Bioavailable Copper	0.001	mg/l	6E-05	5E-05	5E-05	3E-05	6E-05	3E-05	1E-03	6E-05	5E-05	2E-04
Lead (dissolved)	nc	mg/l	0.0018	0.0025	< 0.0010	< 0.0010	0.0017	< 0.0010	0.0016	0.0026	0.0017	0.0017
Bioavailable Lead	0.0012	mg/l	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001
Mercury (dissolved)	0.00007	mg/l	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Molybdenum	nc	mg/l		< 0.0010	0.0053					0.0010	< 0.0010	
Nickel (dissolved)	nc	mg/l	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Bioavailable Nickel	0.004	mg/l	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024
Selenium (dissolved)	0.01	mg/l	0.0031	0.0016	0.0018	< 0.0010	0.0020	< 0.0010	0.0011	0.0017	0.0016	< 0.0010
Zinc (dissolved)	nc	mg/l	0.0030	0.0053	0.023	0.0021	0.0087	0.0027	0.0082	0.0067	0.0064	0.042
Bioavailable Zinc	0.0129	mg/l	0.0005	0.0010	0.0041	0.0004	0.0016	0.0005	0.0015	0.0012	0.0012	0.0076
Chloride	nc	mg/l	< 10	3.1	20	1.8	3.9	8.1	3.6	1.9	5.9	6.1
Fluoride	nc	mg/l		0.097	0.13					0.097	0.10	
Sulphate	nc	mg/l		4.5	45					11	22	
Total Dissolved Solids	nc	mg/l		26	180					35	120	
Phenol Index	nc	mg/l	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
Dissolved Organic Carbon	nc	mg/l		3.8	6.1					24	4.7	

M-BAT for Surface Water (which will be used for leachate):
pH: 8 (8.1)
Ca: 26mg/l (Average value)
DOC: 12.5 (Median value)

			Round 1				Round 2				Round 3			
Sample Lab ID	**Surface Water Freshwater EQS (2015) [FEQS]**		913174	913175	913176	913177	925331	925332	925333	925334	932738	932739	932740	932741
Sample GI ID			SW1	SW2	SW3	SW4	SW1	SW2	SW3	SW4	SW1	SW2	SW3	SW4
Date Sampled			24/10/2019	24/10/2019	24/10/2019	24/10/2019					25/11/2019	25/11/2019	25/11/2019	25/11/2019
pH	nc		9.0	8.9	8.6	9.0	8.5	8.6	8.7	8.4	6.7	7.0	6.6	6.9
Biochemical Oxygen Demand	nc	mg O2/l	5.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
Chemical Oxygen Demand	nc	mg O2/l	13	12	160	13	130	570	260	690	18	< 10	110	41
Alkalinity (Total)		mg/l	58	120	40	37	61	120	22	78				
Chloride	250	mg/l	29	56	22	22	39	64	13	24	23	32	12	21
Ammoniacal Nitrogen	0.78	mg/l	0.17	< 0.050	0.30	0.22	0.061	0.12	0.078	< 0.050	0.051	0.45	0.11	< 0.050
Sulphate	400	mg/l	12	15	< 1.0	< 1.0	9.9	14	5.8	8.7	-	-	-	-
Cyanide (Total)	0.001	mg/l	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
Sulphide	0.00025	mg/l	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	-	-	-	-
Calcium	nc	mg/l	12	30	<5	20	<5	25	9.8	28	71	23	<5	13
Total Hardness as CaCO3	nc	mg/l	38	85	< 15	59	< 15	71	31	77	200	64	34	40
Antimony	nc	µg/l	-	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0
Arsenic (Dissolved)	50	µg/l	< 1.0	< 1.0	1.6	1.5	< 1.0	1.1	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Beryllium (Dissolved)	nc	µg/l									< 1.0	< 1.0	< 1.0	< 1.0
Cadmium (Dissolved)	0.08	µg/l	< 0.080	< 0.080	< 0.080	< 0.080	75	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
Chromium (Dissolved)	4.7	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	3.8	< 1.0	< 1.0	< 1.0
Copper (Dissolved)	nc	µg/l	< 1.0	< 1.0	1.9	1.9	3.8	2.1	1.0	1.3	1.1	1.6	< 1.0	1.7
Bioavailable Copper	1	µg/l	0.03	0.03	0.05	0.05	0.11	0.06	0.03	0.04	0.03	0.05	0.03	0.05
Manganese	nc	µg/l	-	-	-	-	-	-	-	-	16	23	90	12
Bioavailable Manganese	123	µg/l	-	-	-	-	-	-	-	-	16.00	23.00	90.00	12.00
Mercury (Dissolved)	0.07	µg/l	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	-	-	-	-
Nickel (Dissolved)	nc	µg/l	< 1.0	< 1.0	14	14	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bioavailable Nickel	4	µg/l	0.24	0.24	3.40	3.40	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Lead (Dissolved)	nc	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	4.5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bioavailable Lead	1.2	µg/l	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Selenium (Dissolved)	10	µg/l	< 1.0	< 1.0	1.0	1.1	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (Dissolved)	nc	µg/l	-	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0
Zinc (Dissolved)	nc	µg/l	< 1.0	< 1.0	16	14	5.3	2.8	12	6.7	4.0	5.1	8.4	4.1
Bioavailable Zinc	12.9	µg/l	0.18	0.18	2.88	2.52	0.95	0.50	2.16	1.21	0.72	0.92	1.51	0.74
Mercury Low Level	nc	µg/l	-	-	-	-	-	-	-	-	< 0.010	< 0.010	0.025	< 0.010
Dissolved Organic Carbon	nc	mg/l	8.7	7.5	49	15	4.9	4.8	17	9.0	14	11	25	18
Aliphatic TPH >C5-C6	15000	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	15000	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	300	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	300	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	300	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C21-C35	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aliphatic TPH >C35-C44	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	nc	µg/l	< 5.0	< 5.0	< 5.0	< 5.0	-	-	-	-	-	-	-	-
Aromatic TPH >C5-C7	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	90	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	90	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	90	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C21-C35	90	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Aromatic TPH >C35-C44	nc	µg/l	< 0.10	< 0.10	< 0.10	< 0.10	-	-	-	-	-	-	-	-
Total Aromatic Hydrocarbons	nc	µg/l	< 5.0	< 5.0	< 5.0	< 5.0	-	-	-	-	-	-	-	-
Total Petroleum Hydrocarbons	nc	µg/l	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Mineral Oil	nc	µg/l	-	-	-	-	-	-	-	-	< 10	< 10	< 10	< 10
TPH >C6-C10	nc	µg/l	-	-	-	-	-	-	-	-	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C10-C21	nc	µg/l	-	-	-	-	-	-	-	-	< 0.10	< 0.10	< 0.10	< 0.10
TPH >C21-C40	nc	µg/l	-	-	-	-	-	-	-	-	< 0.10	< 0.10	< 0.10	< 0.10
Benzene	10	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	-	-	-	-	-	-	-	-
Toluene	74	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	-	-	-	-	-	-	-	-
Ethylbenzene	nc	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	-	-	-	-	-	-	-	-
m & p-Xylene	nc	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	-	-	-	-	-	-	-	-
o-Xylene	nc	µg/l	< 1.0	< 1.0	< 1.0	< 1.0	-	-	-	-	-	-	-	-
Naphthalene	2	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthylene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Acenaphthene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluorene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Phenanthrene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Anthracene	0.1	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Fluoranthene	0.00063	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Pyrene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]anthracene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chrysene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[b]fluoranthene	0.00017	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[k]fluoranthene	0.00017	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[a]pyrene	0.00017	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Indeno(1,2,3-c,d)Pyrene	0.00017	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dibenz(a,h)Anthracene	nc	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzo[g,h,i]perylene	0.00017	µg/l	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Of 16 PAH's		µg/l	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Phenols		mg/l	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

M-BAT for Surface Water:
pH: 8 (8.1)
Ca: 26mg/l (Average value)
DOC: 12.5 (Median value)

ROUND 1

Sample Lab ID	Surface Water Freshwater EQS (2015) [FEQS]		920218	920219	920220	920221	920222	920223	920224	920225	920226	920227	920228	920229	920230	920231
Sample GI ID			BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	BH11	BH12	BH13	BH14
Date Sampled			05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019	05/11/2019
pH	nc		[A] 7.7	[A] 7.5	[A] 7.7	[A] 7.6	[A] 7.4	[A] 7.4	[A] 7.6	[A] 7.5	[A] 7.5	[A] 8.7	[A] 7.9	[A] 7.7	[A] 7.6	[A] 7.6
BOD		mg O2/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COD		mg O2/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alkalinity (Total)	nc	mg/l	[A] 86	[A] 53	[A] 98	[A] 68	[A] 93	[A] 480	[A] 76	[A] 250	[A] 180	[A] 74	[A] 180	[A] 75	[A] 62	[A] 140
Chloride		mg/l	[A] 70	[A] 63	[A] 14	[A] 10	[A] 25	[A] 25	[A] 14	[A] 25	[A] 18	[A] 11	[A] 16	[A] 51	[A] 31	[A] 20
Ammoniacal Nitrogen		mg/l	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphate		mg/l	[A] 14	[A] 14	[A] 12	[A] 8.1	[A] 34	[A] 15	[A] 12	[A] 40	[A] 14	[A] 8.9	[A] 14	[A] 26	[A] 20	[A] 20
Cyanide (Total)	0.001	mg/l	[A] 0.31	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050	[A] < 0.050
Sulphide		mg/l	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] 0.065	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050	[B] < 0.050
Calcium	nc	mg/l	[A] 18	[A] 14	[A] 13	[A] 14	[A] 14	[A] 87	[A] 43	[A] 60	[A] 24	[A] 12	[A] 53	[A] 17	[A] 9.8	[A] 24
Total Hardness as CaCO3	nc	mg/l	[A] 50	[A] 48	[A] 54	[A] 49	[A] 51	[A] 240	[A] 120	[A] 200	[A] 97	[A] 39	[A] 150	[A] 88	[A] 57	[A] 86
Antimony	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic (Dissolved)	50	µg/l	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Berylium	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium (Dissolved)	0.09	µg/l	[A] < 0.080	[A] 0.11	[A] < 0.080	[A] < 0.080	[A] 0.14	[A] < 0.080	[A] < 0.080	[A] 0.095	[A] < 0.080	[A] < 0.080	[A] < 0.080	[A] < 0.080	[A] < 0.080	[A] 0.17
Chromium (Dissolved)	4.7	µg/l	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0
Copper (Dissolved)	nc	µg/l	[A] < 1.0	[A] 2.0	[A] < 1.0	[A] 4.5	[A] < 1.0	[A] 1.4	[A] < 1.0	[A] 1.5	[A] < 1.0	[A] 2.1	[A] 4.1	[A] < 1.0	[A] < 1.0	[A] < 1.0
Bioavailable Copper	1	µg/l	0.02	0.06	0.02	0.08	0.03	0.03	0.07	0.09	0.04	0.16	0.17	0.07	0.06	0.05
Manganese	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bioavailable Manganese	123	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Dissolved)	0.07	µg/l	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50	[A] < 0.50
Nickel (Dissolved)	nc	µg/l	[A] < 1.0	[A] 1.6	[A] 1.9	[A] < 1.0	[A] 2.5	[A] 9.9	[A] < 1.0	[A] 18	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.5	[A] 1.7
Bioavailable Nickel	4	µg/l	0.19	0.27	0.21	0.25	0.26	0.15	0.36	0.31	0.34	0.76	0.41	0.46	0.41	0.76
Lead (Dissolved)	nc	µg/l	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] 2.1	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] < 1.0	[A] 1.3	[A] < 1.0	[A] < 1.0	[A] 1.9
Bioavailable Lead	1.2	µg/l	0.08	0.14	0.10	0.11	0.14	0.09	0.27	0.29	0.19	0.14	0.19	0.26	0.25	0.43
Selenium (Dissolved)	10	µg/l	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] < 1.0	[A] 1.1	[A] < 1.0	[A] 1.5
Vanadium (Dissolved)	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc (Dissolved)	nc	µg/l	[A] 6.2	[A] 58	[A] 42	[A] 11	[A] 18	[A] 14	[A] 27	[A] 210	[A] 13	[A] 82	[A] 40	[A] 32	[A] 43	[A] 32
Bioavailable Zinc	12.9	µg/l	1.24	17.38	9.74	1.43	6.16	3.59	12.97	98.49	5.32	24.00	12.48	15.61	21.63	14.37
Mercury Low Level	nc	µg/l														
Dissolved Organic Carbon	nc	mg/l	12	7.9	10	19	6.9	11	3.7	3.8	5.2	7.1	6.8	3.9	4.0	4.4
Mineral Oil	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH >C6-C10	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH >C10-C21	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TPH >C21-C40	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total TPH >C6-C40		µg/l	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10	[A] < 10
Aliphatic TPH >C5-C6	15000	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	15000	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	300	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	300	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	300	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C21-C35	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C35-C44	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C5-C7	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	90	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	90	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	90	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C21-C35	90	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C35-C44	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aromatic Hydrocarbons	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	10	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	74	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m & p-Xylene	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	nc	µg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	2	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthylene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Acenaphthene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluorene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Phenanthrene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Anthracene	0.1	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Fluoranthene	0.00063	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Pyrene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]anthracene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Chrysene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[b]fluoranthene	0.00017	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[k]fluoranthene	0.00017	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[a]pyrene	0.00017	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Indeno(1,2,3-c,d)Pyrene	0.00017	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Dibenz(a,h)Anthracene	nc	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Benzo[g,h,i]perylene	0.00017	µg/l	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010	[A] < 0.010
Total Of 16 PAH's	-	µg/l	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10	[A] < 0.10
Total Phenols		mg/l	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030	[A] < 0.030

ROUND 2

920232	920233	925354	925355	925356	925357	925358	925359	925360	925361	925362	925363	925364	925365	925366	925367
BH15	BH16	BH01	BH02	BH03	BH04	BH05	BH06	BH07	BH08	BH09	BH10	BH11	BH12	BH13	BH14
05/11/2019	05/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019	15/11/2019
[A] 7.4	[A] 7.5	7.8	7.5	7.3	7.4	7.1	7.1	7.3	8.5	8.4	8.4	8.0	7.9	7.9	7.9
-	-	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	5.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
-	-	91	150	130	140	29	130	120	520	520	540	980	450	140	150
[A] 72	[A] 23	79	84	40	51	95	510	71	130	180	68	170	96	67	140
[A] 20	[A] 19	70	61	10	10	24	21	13	16	18	11	15	51	28	18
[A] < 0.050	[A] < 0.050	0.067	0.062	< 0.050	< 0.050	< 0.050	0.078	< 0.050	< 0.050	0.10	0.054	0.077	< 0.050	< 0.050	< 0.050
[A] 14	[A] 6.3	13	18	5.3	7.5	32	11	12	27	15	8.8	15	27	20	17
[A] < 0.050	[A] < 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
[B] < 0.050	[B] < 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
[A] 13	[A] 7.8	35	35	28	22	31	69	73	37	43	34	51	40	27	40
[A] 40	[A] 25	93	100	81	65	90	190	200	110	140	99	140	150	96	120
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[A] < 1.0	[A] < 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.5	< 1.0	1.2	9.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[A] 0.11	[A] 0.096	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
[A] < 1.0	[A] < 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
[A] < 1.0	[A] < 1.0	1.5	2.6	< 1.0	5.2	< 1.0	1.6	< 1.0	< 1.0	< 1.0	4.0	2.6	< 1.0	1.9	1.9
0.05	0.04	0.04	0.07	0.03	0.13	0.03	0.03	0.03	0.07	0.07	0.28	0.08	0.05	0.08	0.08
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[A] < 0.50	[A] < 0.50	< 0.50	< 0.50	< 0.50	< 0.50	0.60	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	1.1	< 0.50
[A] < 1.0	[A] < 1.0	< 1.0	9.2	< 1.0	1.6	3.0	9.8	< 1.0	16	< 1.0	< 1.0	< 1.0	< 1.0	3.2	< 1.0
0.36	0.28	0.27	0.26	0.24	0.94	0.21	0.12	0.18	0.82	0.63	0.67	0.29	0.38	0.36	0.38
[A] < 1.0	[A] < 1.0	< 1.0	1.1	< 1.0	4.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	1.1
0.23	0.17	0.11	0.12	0.12	0.47	0.11	0.06	0.12	0.13	0.13	0.14	0.10	0.17	0.14	0.16
[A] < 1.0	[A] < 1.0	< 1.0	< 1.0	< 1.0	< 1.0	2.5	1.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[A] 14	[A] 32	15	58	4.9	38	34	15	11	38	< 1.0	31	10	19	35	20
6.69	12.01	3.67	16.20	1.53	11.03	10.70	3.05	3.44	10.41	0.28	9.04	2.25	6.57	10.65	6.10
4.4	6.0	9.5	8.9	8.2	8.6	8.8	17	8.5	7.8	7.6	7.2	10	5.9	7.0	7.0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[A] < 10	[A] < 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	5100	< 10	< 10	< 10	< 10	< 10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	24	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	210	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	3700	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	3900	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	6.3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	1100	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	59	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	1200	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.010	[A] < 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
[A] < 0.10	[A] < 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
[A] < 0.030	[A] < 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030

ROUND 3

925368	925369	932742	932743	932744	932745	932746	932747	932748	932749	932750	932751	932752	932753	932754
BH15	BH16	BH1	BH2	BH3	BH4	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	BH16
15/11/2019	15/11/2019													
7.7	7.7	6.5	6.2	6.4	6.4	6.8	7.0	7.0	7.0	6.7	6.6	7.0	6.4	6.5
< 4.0	< 4.0	[B] < 4.0	[B] 6.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] 6.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0	[B] < 4.0
140	120	21	< 10	11	11	< 10	16	< 10	< 10	< 10	< 10	< 10	< 10	< 10
71	60	-	-	-	-	-	-	-	-	-	-	-	-	-
20	20	63	48	6.8	11	17	18	9.2	14	51	27	16	17	18
0.057	0.057	0.49	0.061	< 0.050	0.21	0.056	0.086	0.16	0.62	1.0	0.26	0.058	0.058	< 0.050
14	7.3	-	-	-	-	-	-	-	-	-	-	-	-	-
< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
< 0.050	< 0.050	-	-	-	-	-	-	-	-	-	-	-	-	-
31	24	14	11	8.1	5.0	15	25	10	38	21	8.0	19	9.2	7.0
89	67	39	35	24	19	61	100	33	110	98	52	74	32	23
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.3	8.9	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
< 0.080	< 0.080	0.30	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	0.32	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080	< 0.080
< 1.0	< 1.0	1.6	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
2.0	< 1.0	2.0	< 1.0	1.1	1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
0.07	0.04	0.08	0.09	0.07	0.07	0.04	0.04	0.03	0.02	0.04	0.05	0.03	0.06	0.05
-	-	28	33	19	27	680	380	18	38	16	52	80	92	17
-	-	6.56	8.45	6.02	12.30	137.23	51.94	4.72	5.19	2.62	16.26	13.77	27.17	6.07
< 0.50	< 0.50	-	-	-	-	-	-	-	-	-	-	-	-	-
2.7	< 1.0	< 1.0	2.2	< 1.0	1.4	14	< 1.0	< 1.0	1.4	1.5	2.5	1.8	3.5	< 1.0
0.32	0.34	0.17	0.22	0.22	0.21	0.22	0.24	0.21	0.18	0.21	0.21	0.23	0.21	0.20
< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
0.14	0.16	0.08	0.13	0.13	0.11	0.13	0.14	0.12	0.09	0.12	0.13	0.13	0.11	0.12
< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
-	-	< 1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
14	6.9	41	24	44	13	43	7.9	27	15	33	42	43	15	47
4.50	2.37	11.93	10.51	17.47	4.71	15.43	3.00	8.94	4.21	12.25	15.97	14.80	5.57	17.12
		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
6.9	6.3	12	7.8	8.0	8.7	8.0	6.9	8.1	11	8.1	7.8	7.9	8.8	8.5
-	-	< 10	< 10	< 10	< 10	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
-	-	< 0.10	< 0.10	< 0.10	< 0.10	-	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 0.10	< 0.10	-	-	-	-	< 0.10	< 0.10	-	-	-	-	-	-	-
< 5.0	< 5.0	-	-	-	-	< 5.0	< 5.0	-	-	-	-	-	-	-
< 1.0	< 1.0	-	-	-	-	< 1.0	< 1.0	-	-	-	-	-	-	-
< 1.0	< 1.0	-	-	-	-	< 1.0	< 1.0	-	-	-	-	-	-	-
< 1.0	< 1.0	-	-	-	-	< 1.0	< 1.0	-	-	-	-	-	-	-
< 1.0	< 1.0	-	-	-	-	< 1.0	< 1.0	-	-	-	-	-	-	-
< 1.0	< 1.0	-	-	-	-	< 1.0	< 1.0	-	-	-	-	-	-	-
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
< 0.030	< 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030	[B] < 0.030

Appendix E

Geotechnical Risk Register Extract

Geotechnical Risk Register

Project Name	A40 Penblewin to Redstone Cross Improvements	**Client**	Welsh Government
Document Number	A40LVP-GEN-GHS-SWI-TK-ZS-0003	**Current Project Stage:**	KS3 Preliminary Design

Note: Risk that have been struckthrough were developed as part of the Northern Route PSSR and are either repeats or not considered specific to the Southern Scheme

Likelihood		Severity	
1	Very unlikely; Highly improbable, not known to occur	1	Minor harm; Minor damage or loss no injury
2	Unlikely; Less than 1 per 10 years	2	Moderate harm; Slight injury or illness, moderate damage or loss
3	May happen; Once every 5-10 years	3	Serious harm; Serious injury or illness, substantial damage or loss
4	Likely; Once every 1-4 years	4	Major harm; Fatal injury, major damage or loss
5	Almost certain; Once a year or more	5	Extreme harm; Multiple fatalities, extreme loss or damage

Risk Item	Project Risk Reference	Description	Date Identified	Identified By	Status	Project Lifecycle Stage	Likelihood	Severity	Risk Score	Relevant Documentation	Owner of risk	Can the risk be mitigated?	Mitigation Description	Likelihood (After Mitigation)	Severity (After Mitigation)	Risk Score (After Mitigation)	Further Action Required
1	G21	Presence of 'soft' ground along the alignment of the scheme. In particular, this is a risk in the vicinity of the various minor watercourses and low spots along the scheme, and potential for localised high degrees of weathering of the bedrock. Glacial Till is also shown to underlie part of the site. The potential impacts are: - potential for deep seated instability of embankment slopes - high magnitudes of total settlement of embankments, which may be unacceptable in terms of future performance of drainage etc. - high magnitudes of differential settlement, which may be unacceptable in terms of the finished road levels, interfaces with structures, performance of drainage, kerbs etc.	23/05/2017	VTW	Closed (refer to Risk Item 22, 24 and 30)	Construction, Operation	3	5	15	PSSR (including Annex A)	Designer, Contractor	No	Site specific ground investigation to be carried out to identify general ground and groundwater conditions.	2	5	10	Refer to Risk Item 22, 24 and 30
2	G22	Faulting and unfavourable geological conditions resulting in: - possible instability of cuttings and excavations. - possible requirement for slacker/engineered cutting slopes.	23/05/2017	VTW	Refer to Risk Item 30	Construction, Operation	3	3	9	PSSR (including Annex A)	Designer	No	Site specific ground investigation to be carried out to identify general ground and groundwater conditions. CSB (06/04/20) - main cutting away from fault location but eastern extent in an area of GI not completed (refer to Risk Item 30)	2	3	6	Refer to Risk Item 30
3	G23	Potential for the mudstones that are present across the scheme to contain high levels of sulfates and pyritic conditions, which have the potential to: - be aggressive to concrete in contact with the ground leading to deterioration of structures over time. - deterioration/damage to the highway, structures and earthworks due to potential for expansion of soils/rock should they contain pyrite.	23/05/2017	VTW	Refer to Risk Item 33	Operation	3	4	12	PSSR (including Annex A)	Designer	Yes	Sulfate related testing to be undertaken as part of the site specific ground investigation and sulfate assessments to be been carried out in accordance with BRE Digest 1 and TRL 447.	2	4	8	Refer to Risk Item 33
4	G24	Presence of previously unidentified made ground and contamination, and risks posed by known areas of made ground and contamination. Possible sources include, the existing roads, tracks and hardstandings; areas of past fly tipping; infilled pits and quarries; and sewage discharge points. Amongst others, possible contaminants include coal tar, metals, hydrocarbons, asbestos, high bacterial levels etc. Risks include: - potential risks to human health. For example, site operatives during construction, and future maintenance workers. - potential risks to the environment. In particular, water bodies as a consequence of potential exposure to surface water runoff and infiltration via areas of contaminated ground. - potential cost implications if materials are classified as 'unsuitable', and require disposal to an appropriately licenced facility. Possible high costs if materials are to be disposed of as non-hazardous or hazardous landfill classifications.	23/05/2017	VTW	Active	Construction	3	3	9	PSSR (including Annex A)	Designer, Contractor	No	Geo-environmental testing to be undertaken as part of the site specific ground investigation. An observational approach with a contamination watching brief shall be adopted during the ground investigation.	2	3	6	Yes
5	G25	Site won fill material unsuitable for reuse resulting in: - possible need to dry out due to relatively high natural moisture contents, or improve (eg, lime) the material prior to or at the point of placement. - probable need to process the rock, eg through crushing and sorting, prior to placement - to achieve the required grading for use as fill. - alternative sources of fill material required. - additional disposal costs for unsuitable material. Delays during construction and cost implications for all of the above if the proportion of unsuitable material is greater than assessed.	23/05/2017	VTW		Construction	3	4	12	PSSR (including Annex A)	Designer, Contractor	No	Site specific gound investigation to include a suite of suitability/acceptability tests and fidings to be incorporated ino the Stage 3 GDR	2	4	8	Yes
6	G26	Unidentified services resulting in potential damage to services presenting a H&S hazard, disruption to third parties, causing delays during construction, and possible cost implications.	23/05/2017	VTW	Closed	Construction	~~3~~	4	12	PSSR (including Annex A)	Designer, Contractor	No	Comprehensive searches through contacting all mainstream providers ahead of the site specific ground investigation and main works. Contact landowners for existing private drainage and services plans. Appropriate use of a safe system of work by the contractor, which may include cable avoidance equipment and inspection pits.	2	4	8	Yes (service plans obtained to be shared vis PW)
7	G27	Presence of pits, quarries and unidentified pit locations potentially backfilled with animal remains. The risk is biohazard (for example: anthrax, foot and mouth) to human health and environment. See also Risk Item 4 (G24)	23/05/2017	VTW	Active	Operation	2	3	6	PSSR (including Annex A)	Designer, Contractor	No	Desk study carried out to identify locations of known or likely potential backfilled pits. Online walkover to be undertaken which will include searching for and recording any evidence to backfilled pits. Consultation with land owner / occupier to be completed. Watching brief to be adopted during the course of the site specific ground investigation and construction works.	2	3	6	Yes
8	G28	Dip angle of rock bedding is not suited to proposed slope angles for cuttings. There is a risk that low shear angle surfaces may exist within the rock formations, and if these are orientated so that they crop at an unfavourable angle into the cut faces, rock wedge failures are possible. Also see Risk Item 2 (G22)	23/05/2017	VTW		Construction, Operation	2	3	6	PSSR (including Annex A)	Designer	No	Preliminary Sources Study Report completed, which has included obtaining and interpreting field slip and county geological plans, to better inform the local solid geology. Preliminary desing likely to allow for 1 in 2 cut slope angles in rock, which should be suitably robust to ensure stability for most circumstances.	2	3	6	Yes
9	G29	Part of the alignment overlies the Llandeilo Flags Limestone. If this formation is a massive limestone, there is the potential for cavities to be located below the proposed alignment.	23/05/2017	VTW	Closed	Construction, Operation	2	4	8	PSSR (including Annex A)	Designer	No	From the Preliminary Sources Study Report completed, the Llandeilo Flags Limestone are likely to be interbedded limestones and mudstones therefore it is unlikely that cavities are present. Ground investigation to be undertaken to confirm make-up of underlying strata. (Limestone not encountered during GI refer to GIR (A40PRC-ARP-HGT-M02-RP-C-0006))	1	4	4	No
10	G30	Potential to encounter sites of achaeological interest such as burnt mounds which have been noted in the vicinity of the scheme.	23/05/2017	VTW	Active	Construction, Operation	3	3	9	PSSR (including Annex A)	Designer	No	Preliminary Sources Study Report completed which has noted two tumuli (CADW scheduled monuments) are present immediately north of the present day A40 alignment. Archaeological surveys to be undertaken as part of the scheme and any recommendations made shall be followed during construction.	2	3	6	Yes
11	~~G01~~	~~Some areas of the alignment that are at grade may have low CBR results and therefore require ground improvements, this would affect the design leading to increased cost.~~	~~21/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~3~~	~~9~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Ground investigation to target these areas to investigate the ground conditions to inform design~~	~~2~~	~~3~~	~~6~~	~~No~~
12	~~G02~~	~~The alignment overlies multiple bedrock formations which the cutting passes through. This may result in varying strengths and weathering within the cutting, which will affect the design.~~	~~21/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~3~~	~~9~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~The bedrock formations are to be investigated during the ground investigation for bedrock strengths and weathering profiles~~	~~2~~	~~3~~	~~6~~	~~No~~
13	G03	Due to the site overlying superficial deposits with unknown depths there is potential for large depths to be present. The extent of this may also be large areas of the alignment, this may lead to settlements and effect the choice of foundation for structures.	21/05/2019	DH	Closed (refer to Risk Item 22 (G20))	Construction, Operation	3	3	9	PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)	Designer	Yes	Ground investigation to be undertaken to investigate the depth and extent of superficial deposits	2	3	6	Yes
14	~~G04~~	~~The bedrock dip angles and directions within cuttings may cause issues with stability during design, this may effect slope angles~~	~~21/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~4~~	~~12~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Ground investigation to investigate the bedrock dip angles and bedrock strength~~	~~2~~	~~4~~	~~8~~	~~Yes~~
15	~~G05~~	~~The material from the cutting may not be suitable for reuse within the embankment depending on the thickness of bedrock weathering encountered. This would lead to large volumes of imported materials which may extend programme and increase cost.~~	~~15/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~3~~	~~9~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Ground investigation to inform potential material reuse suitability~~	~~2~~	~~3~~	~~6~~	~~Yes~~

Geotechnical Risk Register

Project Name	A40 Penblewin to Redstone Cross Improvements	**Client**	Welsh Government
Document Number	A40LVP-GEN-GHS-SWI-TK-ZS-0003	**Current Project Stage:**	KS3 Preliminary Design

Note: Risk that have been struckthrough were developed as part of the Northern Route PSSR and are either repeats or not considered specific to the Southern Scheme

Likelihood		Severity	
1	Very unlikely; Highly improbable, not known to occur	1	Minor harm; Minor damage or loss no injury
2	Unlikely; Less than 1 per 10 years	2	Moderate harm; Slight injury or illness, moderate damage or loss
3	May happen; Once every 5-10 years	3	Serious harm; Serious injury or illness, substantial damage or loss
4	Likely; Once every 1-4 years	4	Major harm; Fatal injury, major damage or loss
5	Almost certain; Once a year or more	5	Extreme harm; Multiple fatalities, extreme loss or damage

Risk Item	Project Risk Reference	Description	Date Identified	Identified By	Status	Project Lifecycle Stage	Likelihood	Severity	Risk Score	Relevant Documentation	Owner of risk	Can the risk be mitigated?	Mitigation Description	Likelihood (After Mitigation)	Severity (After Mitigation)	Risk Score (After Mitigation)	Further Action Required
16	~~G06~~	~~Potential for difficult excavation as most of the site has no overlying superficial deposits and so bedrock may be encountered at shallow depths, this would result in excavation into hard materials. It will also include a cutting into multiple bedrock strata of differing strengths~~	~~15/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~3~~	~~9~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Bedrock formations to be investigated during ground investigation to gain further understanding of the excavability.~~	~~3~~	~~2~~	~~6~~	~~No~~
17	~~G07~~	~~Localised areas of greater weathering at fault locations within the bedrock.~~	~~15/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~3~~	~~3~~	~~9~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Fault locations to be targeted within ground investigation, however this could be difficult to locate on site.~~	~~3~~	~~2~~	~~6~~	~~Yes~~
18	~~G08~~	~~Unexpected ground conditions due to limited historical ground investigation available along proposed alignment. This could result in the design being unsuitable for the encountered ground conditions on site.~~	~~15/05/2019~~	~~DH~~	~~Active~~	~~Construction~~	~~4~~	~~3~~	~~12~~	~~PSSR (A40PRC-ARP-HGT-M02-RP-C-0001)~~	~~Designer~~	~~Yes~~	~~Ground investigation completed but areas where access not possible (refer to G20)~~	~~2~~	~~3~~	~~6~~	~~Yes~~
19	G17	Site specific topographic survey has been undertaken in places to supplement the LiDAR survey. There is a risk that errors could be present at the transitions between the two. This could lead to earthworks being larger than anticipated.	13/02/2020	AT	Active	Construction	3	3	9	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Further topographic survey could be undertaken at the transitions to ensure the model is representative.	1	3	3	Yes
20	G18	High embankments (>7.5m) may become unstable if constructed from site won material (Class 2 general Fill) or imported Class 2 Fill - slacker slopes may be required that will impact land take	13/02/2020	AT	Active	Construction	3	3	9	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Design to consider use of Class 1 embankment shoulders overlying Class 2 fill or geogrids with Class 2 fill	1	3	3	Yes
21	G19	Instability of cut faces due to unfavorably orientated fractures and joints within the rock mass - risk of slacker slopes being required	13/02/2020	AT	Active	Construction	3	4	12	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Contractor	No	Additional measures to be incoporporated to stabilise the cut face (i.e. rock bolting)	3	2	6	Yes
22	G20	Glacial deposits have been identified to underly the scheme between chainage 0+740 and 1+400. Ground Investigation to identify the extents of this material was proposed however not all was completed due to site constraints, particularly between chainage 1+200 and 1+400. There is a risk that softer materials could be present beneath the embankment at this locations which could result in stability issues.	13/02/2020	AT	Active	Construction, Operation	3	4	12	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Design to consider this risk of softer Glacial Deposits in the slope stability assessments - allowance for dig and replace during construction may be required. Any residual risk is to be communicated to the Contractor.	3	3	9	Yes
23	G21	The B4313 Redstone Road is proposed to cross over the mainline cutting at chainage 0+580. Approach embankments associted with the bridge are located on the crest of the mainline cutting. There is a risk that the additional loading from these embankments could cause instability of the cutting slopes, and damage/failure of the bridge.	13/02/2020	AT	Active	Construction, Operation	4	4	16	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Design of cutting slopes to consider the additional loading from the overbridge and embankments. Consideration of partial dig and replace of weathered bedrock to ensure embankment forunded on engineered fill overlying intact rock. Cosntruction sequencing to also be considered to prevent unfavourable temporary load cases	3	4	12	Yes
24	G22	The ground investigation was unable to access the vegetated area around chainage 0+800. As such there is a risk that areas of soft ground could be present in this area linked to the vegetation and water course near here.	13/02/2020	AT	Active	Construction	2	3	6	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Design to consider this risk in the slope stability assessments. Any residual risk is to be communicated to the Contractor.	2	2	4	Yes
25	G23	Groundwater monitoring across the site has indicated the groundwater level to be near surface. As such there is a risk of encountering groundwater within the cuttings and degradation of the cutting formation due to elevated pore pressures at the base of the cuttings	13/02/2020	AT	Active	Construction, Operation	5	4	20	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Cutting design to consider this risk. Drainage to be incorporated within the cuttings.	5	3	15	Yes
26	G24	The embankments on the scheme cross different geological strata boundaries. As such there is a risk of differential settlement from these.	13/02/2020	AT	Active	Construction, Operation	2	3	6	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Ground investigation suggests that weathered bedrock irrespective of strata type will behave in a similar manner. Soft spots in the Glacial Deposits identified and allowance for dig and replace during construction will be required to mitigate risk of differential settlement.	2	2	4	Yes
27	G25	Ground investigation has identified that the material excavated from within the cuttings may vary in terms of engineering behaviour (cohesive vs granular) or may change engineering behaviour during excavation, haulage and compaction (i.e. breakdown of mudstone causing increase fines) that may impact slope stability of cut faces and embankments. Impact on earthworks geometry i.e. slacker slopes may be required	17/02/2020	AT	Active	Construction	4	4	16	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Embankment design to consider likely variation in material and possible construction controls to avoid mechanical breakdown. Marginal material may require placement within core of the embankment away from the side slopes (further impact on construction sequence and programme)	3	4	12	Yes
28	G26	Shallow groundwater identified as part of ground investigation that may cause pore pressure build up below base of embankments causing stability issues	18/02/2020	CB	Active	Construction, Operation	4	4	16	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Design to incoporate the use of drainage blanket/starter layer below the base of embankments (this will require imported fill)	1	4	4	Yes
29	G31	Soakaway testing not conducted at all attenuation ponds (only in Ponds A and B) and lack of information may impact design assumptions adopted for the attenuation basins (currently no inflitration to the ground proposed) possible opportunity to update design if more infomation becomes availiable	02/04/2020	CB	Active	Construction, Operation	1	1	1	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Contractor	Yes	Additional GI (including soakaways) at pond locations will verify design assumptions (may provide opportunity to ammend the preliminary design approach)	1	1	1	Yes
30	G32	Due to land access constraints, the following works were cancelled: RCE-TP16 and TP17; and RCE-DS11 to 15. This presents a gap in the ground condistions associated: - The embankment and culvert foundation along the Afon Marlais - potential for soft soil to be present that may require treatments (i.e. dig and replace) - The approach to the Penblewin roundabout - low height to grade earthworks that may be impacted by poor insitu CBR conditions	02/04/2020	CB	Active	Construction, Operation	2	2	4	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer, Contractor	Yes	Preliminary design to consider the risk of adverse ground conditions and completion of the GI prior to detailed design	1	2	2	Yes
31	G33	Glacial Till extends further than predicted from the geological map and the GI information. For example RCETP03 may have encountered Glacial Till that if encountered in the cut face could pose localised stability issues due to the lower effective strength of the material - localised slackening of the cut slope may be required	02/04/2020	CB	Active	Construction	2	2	4	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Impact on design to be considered in GDR	1	2	2	Yes
32	G34	Lack of information on the Haverford Beds (Gasworks Mudstones) to the west of the scheme - impact on cut and attenuation cutting design that may require slacker slopes and information on reuse potential as fill	02/04/2020	CB	Active	Construction	2	3	6	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer, Contractor	Yes	Impact on cutting design and material reuse to be considered in GDR and recommendation for further GI if required	1	3	3	Yes
33	G35	No BRE testing within the Haverford Beds and Dicranograptus Beds that may result in more onerous concrete classification for buried structures but the following to inform the risk - Haverford Beds – testing was conducted as part of the LVP scheme within mudstone of the Haverford Beds (reported as DS-1 AC-1). A culvert is proposed towards the start of the scheme and within Attenuation Pond A. The information from LVP will be used to inform the BRE assessment. - Dicranograptus Beds – There are no foundations proposed within the strata (no bridges, culverts will be founded in the Glacial Till).	02/04/2020	CB	Active	Construction	2	3	6	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer, Contractor	Yes	Data from LVP scheme to be used to inform the assessment and further detailed design GI will add to the data set for these materials	1	3	3	Yes
34	G36	Ground investigation has identified that the weathered and intact material forming the cuttings is argillaceous and weak and may over time deteriorate causing a change is engineering properties that may impact the performance of the cuttings. Risk that slope instability may occur and slacker slopes are required	02/04/2020	CB	Active	Construction	4	4	16	GIR (A40PRC-ARP-HGT-M02-RP-C-0006)	Designer	Yes	Cutting design to consider likely deterioration of material and assess the behaviour of any existing cuttings in the surrounding area	3	4	12	Yes

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

Subject of Review:	Ground Investigation Report

Document/Certificate Details:

Document ref no.	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date information received:	26-Feb-2020
Date certificate/comments returned:	26-Mar-2020

Certificate STATUS *Received* *Received with comments* *Returned*	*Received with comments*

Documents Details:

List of supporting documents:	a)	
	b)	
	c)	
	d)	
	e)	
	f)	
	g)	
	h)	
	i)	

Review Details:

Name of Reviewer(s):	
JDW	Jason Williams

Comments status key: **C** = Comment, **OBS**=observation only **CFA** = Comment for future action,

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

Subject for Review:	Ground Investigation Report
Document ref No	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
General				

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

Subject for Review:	Ground Investigation Report
Document ref No	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
1	**3.2.1** Please discuss limitations of both the LiDAR data and Topographical survey. It is understood from discussions with the design team that there may be significant discrepancies in some of the survey data. Please discuss in more detail. Comment by: JDW	CFA	The text is Section 3.2.1 is to be updated as follows: *"The topography along the Scheme has been informed by a combination of LiDAR (digital terrain) data from the LIe LiDAR Composite Datase (Natural Resources Wales database accessed in February 2020) and a topographic survey (dated 07/11/2019). The aim of this topographical survey was to verify the Lidar survey at key locations along the scheme, such as along watercourses and at tie-in points. Where differences in ground level are apparent between the two sets of survey, the information from the topographic survey has been adopted. As part of the detailed design a site-specific topography survey is recommended."* As way of background, the design team has compared the Lidar and the topographic survey results at key locations along the scheme. In conclusion the level differences are generally around 10mm to 300mm. Larger differences are associated with the following areas: • Western arm of Penblewin Roundabout (550mm lower) • Afon Marlais (over 5m lower); • Tie in toe B4313 at Blaenmarlais Care Home (433mm higher than LiDAR) • Watercourse south of Redstone Cottages (6.5m lower). The findings are to be presented in a file note (PW ref A40PRC-ARP-VTO-SWI-FN-C-0002). In terms of risk it will be recommended that a scheme wide topographic survey is conducted to inform detailed design.	

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

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Document ref No	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
2	**3.10.10 Contaminated Land** The Environmental Statement accompanying this scheme records a hydrocarbon spill experienced during the ground investigation as a potential long-term source of contamination. Should this not be discussed within this section? Comment by: JDW	C	The following text is to be added as 3.10.11: "*In addition, a pollution incident occurred during the ground investigation during drilling works at borehole BH09. This involved a breakage in the hydraulic pump attached to site machinery resulting in 4.5 litres of fuel spillage at chainage 1+320.*"	
3	**3.11.12** It is stated that an Arup Engineer was on site for the majority of the field works. Please indicate what element of the works may not have been supervised? Comment by: JDW	CFA	The Arup engineer was on site full time for the duration of the main site works. However, the site works were run concurrently across a 6km area, as such not everything was observed by the engineer. Arup did not observe the groundwater monitoring and any works undertaken by the GI Contractor outside of the main site works period. The sentence will be updated as follows: "*An Arup engineer was present on site full time to observe the fieldwork component of the ground investigation works".*	

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

Subject for Review:	Ground Investigation Report
Document ref No	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
4	**4.3.1** Why were soakaway tests not undertaken at the location of all the proposed attenuation ponds? Should this lack of testing at all locations have been included as a risk within the risk register? Comment by: JDW	C	At the time of specifying the GI the preliminary drainage design was still being developed. As such the locations of all the attenuation ponds had not be determined. The findings of the soakaway testing conducted suggest that drainage via soakaway to the ground is not feasible (located at the two larger ponds Pond A and Pond B). This approach has been applied to all ponds. The preliminary design approach is for no soakaways. This will be included in the risk register as further GI may present an opportunity to modify the design approach.	
5	**4.3.4** It is stated that a number of exploratory holes were cancelled due to landowner access issues. Should not the lack of information as these locations be raised as a risk in the risk register? Comment by: JDW	C	The lack of information will be raised in the risk register. The holes RCEDS11 to 15 were proposed to be located below embankment 2b to assess if there is any soft soil associated with the existing stream. There is information in the form of boreholes and trial pits within the vicinity of the DS holes but there is a gap in information along the alignment of the stream (RCEDS11 and RCEDS13 were not conducted). RCETP16 and 17 are located towards Penblewin Roundabout where there is a lack of specific ground investigation information.	

A40 Penblewin to Redstone Cross Improvements

Schedule of Comments and Responses

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Document ref No	A40PRC-ARP-HGT-M02-RP-C-0006 P01
Submission reference:	SOC–SUB-OA-071 Rev A
Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
6	**4.4.1** It is recommended that the locations of the in situ CBR tests are clearly marked on the attached Drawing Numbers 2 and 3. Comment by: JDW	C	As discussed, location of CBR tests in terms of trial pits will be added to the text in the GIR.	
7	**4.5.1** Whilst it is apparent from Drawings 2 and 3 that trial pits were undertaken at the locations of some of the attenuation ponds the drawings do not explicitly show that soakaway testing was carried out at these locations. It may therefore be prudent to identify the soakaways on these drawings. Comment by: JDW	C	As discussed, location of soakaway tests in terms of trial pits will be added to the text in the GIR.	
8	**5.3.1** This paragraph states that topsoil was encountered to a depth of up to 0.6m bgl. Having reviewed the logs, I cannot see a recorded depth of 0.6m. Please confirm that this depth is correct. Comment by: JDW	CFA	The value of 0.6m was taken from RCEDS04 in error. The maximum topsoil thickness recorded is 0.4m and the average is 0.28m. The text will be amended to as follows: *"…..ranging in thickness from 0.1m to 0.4m and on average around 0.3m thick."*	

Schedule of Comments and Responses

Subject for Review:	Ground Investigation Report
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Date certificate/comments returned:	26-Mar-2020

Comment Ref:	Comments	Comments status	Response to Comments	Further Comments *(To be completed by the Employer if required)*
9	**5.5.3** BH08 records collapse of material for a depth of 1.0m below the ground water level. This is not discussed in the text. Please discuss the implications of this in the text. Comment by: JDW	CFA	Noted. Following text to be added to 5.5.4: *"Borehole collapse was recorded in RCEBH08 from 6.5 to 7.5m depth. Air mist flush was used from 4.5m depth that may have flushed out a more granular layer in the Glacial Till but based on the borehole log there is no evidence to confirm this".* The proposed scheme is located on embankment over the location of the borehole. Based on the site wide Glacial Till information, the presence of loose collapsible ground or voids is not anticipated. As such the risk of constructing above this area in terms of differential settlement of the embankment is considered low.	
10	**5.5.3** Typo, Borehole 6a and 6b ID appear to be incorrect. Comment by: JDW	OBS	The typo will be corrected as follows: *"RCEDS06a, RCEDS06b".*	
11	**5.5.6** The characteristic value of Bulk Unit Weight recommended is at the very upper end of the range of values recommended by BS8004:2015. Please provide further discussion of why this value is considered appropriate. Comment by: JDW	CFA	The value has been based on the laboratory determined values and is considered site specific. The oedometer testing recorded a single test result 1.8Mg/m^3 with a further 6 tests recording values of 2.2 to 2.37Mg/m^3. The characteristic value of 2.2Mg/m^3 is deemed reasonable on this basis.	

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12	**5.5.9** The Casagrande chart referenced in this paragraph appears to indicate clay material to be off high plasticity. This is not discussed in the text. Please provide a discussion of why these test results are not considered relevant. Comment by: JDW	CFA	A single test result falls within the high plasticity clay category associated with RCEDS07. On examination of the log there is no clear indication on why the material would be high plasticity (based on the secondary granular components). However, 84% of the material tested passed the 425micon sieve that suggests a reduced granular component and may affect the plasticity of the material. The above text will be included in 5.5.9 for completeness.	
13	**5.5.22 & Table 5** Should the drained Youngs modulus symbol be (E')? Comment by: JDW	OBS	Noted. The typo will be corrected to E' for the drained Youngs modulus.	

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14	**5.6.5** Given the variation in the colour of the clay material encountered overlying the gravel of the weathered Haverford Beds, might this material be glacial till? Comment by: JDW	C	The material is notably different in colour to the underlying Haverford Beds and the colour is typical of the Glacial Till encountered towards the centre of the scheme. However, based on the geological drift map the trial pit is outside of the anticipated location of Glacial Till. The material is absent in the RCETP02 to the west and absent in RCEBH15 and RCEDS03 to the east. Due to the limited information the material is to remain as part of the Haverford Beds strata. However, as the material is located within a cut the potential for the material to be Glacial Till will be presented as a consideration in 7.2.2 (c) and in the risk register.	
15	**5.6.7** Review of the borehole logs appears to indicate core loss in the 1 to 3.5m bgl range and to extend to a depth of 10m bgl. The text appears to indicate the zone of core loss is between 5.6m and 8m bgl. Please discuss the engineering implications of the zone of core loss at shallow depth within the text. Comment by: JDW	CFA	Noted. The text will be amended as follows: *"Zones of core loss were noted from 1.5m to 10m depth ranging in thickness from 0.1m to 2.5m."* The frequent core loss recorded is likely to be caused by the fractured nature of the rock (there is no other evidence in the borehole log to suggest why the core loss has occurred). The engineering implications of the fractured nature of the intact rock is discussed in 5.6.24 and in 7.2.2 (c).	

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16	**5.6.8** General comment regarding material parameters of both the weathered and intact Haverford Beds. This formation is either encountered as a Mudstone or Sandstone. However, no attempt has been made to develop material parameters for either material and they are treated as a homogenous unit. Please provide explanatory text justifying this decision. Comment by: JDW	CFA	Agreed that the Haverford Beds will be comprised of mudstone and sandstone. The GI information within the strata is predominantly in the sandstone material with a single trial pit in the mudstone. Based on the GI information, around two thirds of the cut will be within sandstone but there will be a third in the mudstone. The material (as a whole) is fractured and is likely to behave as a gravel (as will the mudstone based on RCE TP01). As such the material parameters were determined based on a homogenous unit that will behave as a gravel. As the information on the mudstone is limited it will be included in the geotechnical risk register.	
17	**5.6.15** Given that only a single dry density test was carried out, how representative is the single OMC value considered be? Is this limited amount of testing considered to represent a risk? Comment by: JDW	C	Agreed that a single test is not considered representative. The test was conducted in the clay material interpreted to be part of the Haverford Beds. The clay may be limited in extent but there is a risk that more material could be encountered that has limited testing. The risk will be included in the geotechnical risk register. As part of the GDR material reuse assessment findings from the LVP scheme will be incorporated.	

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18	**5.6.15** Given that only a single dry density test was carried out, how representative is the single OMC value considered be? Is this limited amount of testing considered to represent a risk? Comment by: JDW	C	See response to Comment 17.	
19	**5.6.24** The variability of the "soil" material, with it encountered as either fine or coarse grained material could have a significant effect on the stability of cuts slopes and on its performance as a fill material. Has this been considered during the preparation of the GIR and if so please provide further information on this assessment? Comment by: JDW	CFA	The text in Section 7 of the GIR will be developed to include considerations on the design approach for assessing slopes with potentially variable material (7.1.2, 7.2.2 and 7.3.2). This can then be addressed in the Stage 3 GDR.	

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20	**5.6.27** The Kinematic stability of the proposed cuts is a potential significant risk with the potential to result in shallow slope angles or stabilisation. Furthermore, the in-situ mudstone has the potential to weather significantly once exposed. Has any attempt been made to review how cuttings in similar ground conditions locally behaved in the long term? Comment by: JDW	C	For the Haverford Beds it is likely that the cut within the mudstone is likely to be within the weathered material and will behave as a soil (refer to response to Comment 16). Information regarding as built information was requested from Welsh Government but the information was limited to drainage drawings and a GI Specification for the scheme to the east of LVP. No information on cuts within the Haverford Beds within the surrounding area have been obtained. There is a large cutting within the Slade and Redhill Formation to the east of the LVP scheme that was constructed in 1985. The cutting has been described in the LVP GIR and the observations will be incorporated into the P2RC GDR to inform the long-term behaviour of the two cuttings within the same formation.	

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21	**5.8.4 & Figure 26** In Figure 26 5 of results plot PI values below the A Line indicating the material to behave as a Silt. These results are not discussed in the text. Comment by: JDW	C	Noted that three test results fall below the A-Line. The text will be amended as follows: "*High to extremely high plasticity clay and silt results are recorded that relate to the high moisture content samples (above 30%) from RCETP05, RCEDS01, RCEDS03 and RCEDS05".* The text after is to remain unaltered as it states what the material is logged as in these holes. The final sentence is to up be amended as follows: "*There is no other evidence to indicate why the tests from these holes are behaving as extremely high plasticity clay or silt".* It is possible that the material has been subjected to increased weathering and the material has broken down to contain increased fines and so can retain a higher moisture content and exhibit a high plasticity index.	
22	**5.8.6 & Figure 26** In Figure 26 5 of results plot PI values below the A Line indicating the material to behave as a Silt. These results are not discussed in the text. Please discuss the durability of this material for reuse as a fill material. Comment by: JDW	CFA	Comment is a repeat of Comment 21. The considerations regarding the durability of the material as fill are touched on in Section 7 of the GIR but will be addressed further in the Stage 3 GDR. (Refer to response to Comment 41 for further details)	

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23	**5.8.12** It should be stressed that the material parameters of undrained shear strength apply to the weathered Slade and Redhill beds when it is encountered as fine grained material. This parameter will not be appropriate for coarse grained material. Comment by: JDW	C	The sentence will be amended as follows: "*Based on the material descriptions of predominantly firm an undrained strength of around 50kPa is anticipated for the cohesive Weathered Slade and Redhill Formation".*	
24	**5.9.3** It should be stressed that the material parameters of undrained shear strength apply to the weathered Slade and Redhill beds when it is encountered as fine grained material. This parameter will not be appropriate for coarse grained material. Comment by: JDW	C	Comment is a repeat of Comment 23.	
25	**5.9.3** Typo in Trial Pit ID No. Comment by: JDW	OBS	Typo to be amended to read TP05.	

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26	**5.9.13** Please provide the RocLab outputs in an Appendix. This should follow the same approach as undertaken in the GIR for the Penblewin to Llandewi Velfrey scheme. This comment applies to any strata where RockLab has been used. Comment by: JDW	CFA	Appendix of RocLab results to be added to the GIR.	
27	**5.10.13** With on a single sample generating a fines content of less than 25% might this result not be a statistical outlier. Comment by: JDW	OBS	Noted. The result is very similar to the grading curves of the intact material (as presented on Figure 42) and may reflect a less weathered material.	
28	**5.10.19** Please provide commentary on the process behind the selection of a characteristic SPT N value of 40? Comment by: JDW	CFA	The characteristic SPT N of 40 is based on the average value of the 5 test results within the weathered material. This includes the lower value of 15 from RCEDS09. The lowest value was not adopted (as the characteristic value) as the test was conducted within a zone of borehole collapse and is not considered representative. The text in 5.10.15 will be amended to include the above commentary.	

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29	**5.10.32** Please provide a reference for the value of Mr selected. This applies to all further references to an Mr value. Comment by: JDW	CFA	The value of Mr has been selected based on the Table 4 clause 2.2.2.3.1.12 and Appendix A of BS8006:1986. This reference also applies to all other references to Mr values. References to Mr will be amended as follows: *"An Mr value of 75 has been selected (corresponding to uncemented mudstones (Table 4 and Appendix A of BS8006:1986))".*	
30	**5.10.33** This paragraph appears to imply that a soakaway test was undertaken below groundwater level. Is this the case? Comment by: JDW	CFA	Seepages were noted in RCETP12 at 2.7m. On completion of the trial pit and prior to the soakaway test, infill of the trial pit with groundwater was not recorded. The seepages do suggest a shallow groundwater level above the level of the soakaway test and may explain the lack of infiltration. The above text will be included in 5.10.33.	
31	**5.11.18** An average of two values has been used to calculate the characteristic PI. It is not normally good practice to take an average value in such a small sample number and one would normally expect the lowest value to be used as a characteristic value. Comment by: JDW	C	If the lowest PI of 12% is adopted this would increase the f_1 coefficient to around 6.5 and would increase the correlated c_u to around 200kPa or would increase the drained strength (ϕ') to 28°. It is proposed that the higher PI of 17% is adopted with an f_1 coefficient of around 5 to keep the correlated c_u of around 150kPa and the drained strength (ϕ') to 27°. 5.11.16 and 5.11.18 will be amended for a PI of 17%	

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32	**Table 8** As discussed previously it is suggested that this table is amended to more clearly differentiate between the fine grained and coarse grained components of each material. Comment by: JDW	CFA	Table to be amended.	
33	**Table 8** Only drained elastic modulus values have been provided. It is suggested that undrained values should be included for fine grained soils. Comment by: JDW	C	Table to be amended.	
34	**Table 8** Why have compressive strength values not been presented for the rock strata? Comment by: JDW	C	Table to be amended.	
35	**Table 8** The phi value presented for the Haverford Beds in the Table is 37 degrees, the text states 35. Please correct accordingly. Comment by: JDW	CFA	The value of 35° presented in 5.6.27 is related to predicted joint shear strength in sandstone to be used in the kinematic stability analyses. The value of 37° is the mass strength if the rock is fractured and treated as a “soil” type material.	

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37	**Table 8** The phi value presented for the Weathered Llandeilo Limestone in the Table is 27 degrees, the text states 26. Please correct accordingly. Comment by: JDW	CFA	The value presented in 5.11.18 is 27° *and has been used in Table 8.*	
38	**5.13** There has been a limited number of BRE tests carried out on some of the materials, in particular the Haverford Beds and the Dicranograptus Beds. Has the limited amount of data been considered in the assessment of concrete aggressivity and should this be included in the risk register. Comment by: JDW	C	The absence of testing within the Haverford Beds and Dicranograptus Beds will be included in the risk register. As part of the assessment of the risk the following will be noted: • Haverford Beds – testing was conducted as part of the LVP scheme within mudstone of the Haverford Beds (reported as DS-1 AC-1). A culvert is proposed towards the start of the scheme and within Attenuation Pond A. The information from LVP will be used to inform the BRE assessment. • Dicranograptus Beds – There are no foundations proposed within the strata (no bridges, culverts will be founded in the Glacial Till).	

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39	**7.1.2** This states that the material parameters presented in Table 8 are based on the assumption that weathered non intact rock strata behave as a granular material. However, material parameters such as undrained shear strength and PI that are associated with fine grained cohesive soils are presented in the same table. Comment by: JDW	C	Noted. Table 8 has been updated to differentiate between the cohesive and granular materials. 7.1.2 has been updated as follows: "*The weathered bedrock encountered during the ground investigation was predominantly recovered as a gravel but some of the classification testing suggests that the material could behave as a cohesive material. It is recommended that the Stage 3 GDR considers the impact of the weathered material behaving as a granular or cohesive material and the impact of the material degrading in cut faces and in embankments due to weathering or breakdown during excavation, haulage and compaction.*" The range in behaviour will be assessed as part of the Stage 3 GDR so that the geotechnical risk associated with the breakdown of the material can be developed further.	

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40	**7.2.2 a** This states that the majority of the weathered "soil" will behave as a granular material. However, there is clear evidence from much of the laboratory testing that its is often encountered as a predominately clay material. Furthermore, the long term weathering characteristics of the granular material have not been discussed. Given that the gravels are formed from argillaceous material there is a risk that any exposed face may deteriorate over time to form a clay with a corresponding change its material parameters. It is recommended that a discussion of the potential impacts of the weathering on the performance of any cut slope is considered in the text and if necessary, a corresponding additional risk item is added to the risk register. Comment by: JDW	CFA	Noted. The long-term weathering impacts on the cut stability design is to be considered in the Stage 3 GDR. The following is to be added to the end of 7.2.2 a: *"There is a risk that the exposed weathered granular material could break down over the design life of the cut due to the material being argillaceous and weak. The preliminary design will need to consider the following that may impact cut slope angles and land take:* • *The long-term weathering behaviour of the argillaceous granular material exposed in the cut face;* • *The impact of the weathered granular material breaking down and behaving as a cohesive material."*	

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41	**7.2.8** There is no discussion provided on the viability of the excavated material as a fill material. Given that compaction testing has been undertaken on a number of material types the implications of the results should be discussed. The potential for the long term weathering of granular fills excavated from weathered mudstone and siltstone should also be considered. It is noted that slake durability testing was not been undertaken on any of materials likely to be excavated and reused. Therefore, an assessment of durability has not been possible. Comment by: JDW	C	The following text will be included as 7.2.6 regarding the compaction testing: *"The compaction testing suggests that the weathered material from the Slade and Redhill Formation (Cutting 2 and 3) may require some form of treatment (i.e. drying) to ensure that the moisture content is reduced slightly to satisfy the MCV requirements of general fill. For example, the initial moisture content of the weathered material would result in MCVs of less than 7. The requirement of any material treatment prior to placement will need to be considered in the Stage 3 GDR. It is recommended that the testing conducted as part of the A40 LVP scheme is incorporated as part of the Stage 3 GDR reuse assessment."* The effect of long-term weathering of the granular fills is to be considered in the Stage 3 GDR (i.e. the impact of increased fines and reduction in strength or change in behaviour from granular to cohesive). When placed in an embankment it is anticipated that the weathering may locally affect the material below the side slopes. Consideration on the requirement of selecting the excavated material to ensure material less susceptible to weathering is placed towards the shoulders of the embankments is likely to be required. The above is to be added as 7.3.2. In addition, the presence of vegetation combined with the 1:2 side slopes (to shed surface water) are likely to inhibit the development of weathering within the material. This will be considered in the Stage 3 GDR. It is proposed that the slake durability testing conducted for the LVP scheme for the mudstone is commented on in the Stage 3 GDR within the material reuse assessment (classified as medium to medium high durability). Sentence added to 7.2.6 on durability testing.	

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42	**7.4** It is noted that some of the attenuation ponds proposed may be of considerable depth. The slope stability of the pond side slope should be considered as part of their design and this has not been discussed in the text. It is recommended that a discussion of the potential impacts of the in situ soils on the stability of attenuation pond sides slopes is discussed Comment by: JDW	CFA	Paragraph 7.4.1 is to be amended as follows: *"Attenuation ponds are proposed that are to be excavated to depths of 1.5 to 4m into the existing ground. Several the ponds are located adjacent to the mainline earthworks and the preliminary design will need to consider the following:* • *Stability of the pond excavation and the associated implications on the stability of the mainline earthworks adjacent to the ponds.* • *The pond stability assessment will need to consider the impacts of long term weathering on the engineering behaviour of the cut material.".*	
43	**Figures** In some of the geological cross sections, borehole logs overlay each other and are not visible. Comment by: JDW	OBS	Figure to be updated (Note – figure to be finalised as part of final issue due to remote working issues with gINT)	
44	**Figure 4** Key misplaced, material symbols overlapping the Colour Legend. Comment by: JDW	OBS	Legend to be amended to avoid overlap	

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45	**Project Risk Register Extract** This is not a specific Geotechnical Risk Register, it is merely an extract from the overall project risk register and does not provide any information on the mitigation measure that may be employed to reduce the individual risks. Please replace with a Geotechnical specific risk register similar to that in the PSSR. Comment by: JDW	CFA	The Geotechnical Risk Register to be updated and to adopt the general format presented in PSSR.	
46	**Factual Report** The Factual report appears to be of very low quality with a considerable number of typos noted throughout the logs. Furthermore, the log for borehole RCEBH06 indicates probable boulder clay to be present underlying a mudstone band at a depth of 8.50m bgl. This is clearly incorrect. The above raises concerns regarding the quality of the ground investigation data received. Comment by: JDW	OBS	Noted. The error picked up in RCEBH06 was missed but our interpretation has not incorporated this error. The issues with the factual report are not proposed to be addressed as part of this GIR. Issues regarding typos in the logs will be pushed back to the GI contractor to ensure that the quality of the report is acceptable for the tender information.	

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Welsh Government

A40 Penblewin to Redstone Cross Improvements

WFD Compliance Assessment

A40PRC-ARP-EWE-SWI-RP-LE-0001

P03 | S3

13/03/20

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Background to the WFD

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1 Introduction

1.1 Overview of the Project

1.1.1 This report assesses the proposed widening of the A40 from Penblewin Roundabout to Redstone Cross (the "scheme") in Pembrokeshire for compliance with the Water Framework Directive (WFD). An overview of the WFD is provided in Appendix A.

1.1.2 The WFD has been in force since 2000 and is currently the largest and most influential piece of European Union (EU) legislation relating to the water environment. The Directive was transposed into UK law by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. NRW is the competent authority responsible for delivering the Directive in Wales. The Directive requires that Environmental Objectives are set for all surface and groundwater water bodies to enable them to achieve 'Good Ecological Status' (GES) – or 'Good Ecological Potential' (GEP) for Heavily Modified and Artificial Water Bodies – by a defined date. Information on how the WFD status is determined is detailed on Appendix B.

1.1.3 The scheme is 1.8km in length from SN 10344 16048 to SN 11993 16641 (Figure A40PRC-ARP-HML-SWI-DR-D-002) and consists of improvements along the entirety of the scheme.

1.1.4 The scheme alignment broadly follows the watershed crest between the Cleddau and Taf catchments. West of Penblewin, the scheme is in the Taf catchment before crossing into the Cleddau catchment near Redstone Cross. As the scheme follows the ridgeline, the topography of the proposed alignment is flat relative to the local landscape. There are three areas of cutting between Penblewin roundabout and the eastern extent of the scheme.

1.2 Purpose of Document

1.2.1 Under the WFD, all proposed schemes with the potential to impact upon WFD-designated water bodies must be assessed to ensure:

a) no deterioration of the current status or potential of any WFD quality elements; and

b) no prevention of future attainment of the 'good' status or potential objectives of any WFD quality elements.

1.2.2 This report follows guidance produced by Natural Resources Wales (NRW)[1] and the Planning Inspectorate (PINS)[2] to assess whether proposed activities have the potential to adversely impact upon the various WFD quality elements of the relevant water bodies. The report also outlines any associated impact mitigation that is required to ensure compliance of the proposed works with WFD objectives.

1.2.3 This assessment is based on currently available NRW WFD baseline data (see Section 1.3) and scheme information. This assessment should be considered as a 'live' document that should be updated if:

a) NRW update or provide additional WFD baseline data for the relevant water bodies; and/or

b) Significant changes to the nature, alignment, scale or construction methods of the Scheme are made.

1.2.4 NRW has provided a response on the environmental scoping report. Activities noted as having the potential to cause deterioration or prevent a water body from meeting its objectives will be subject to further assessment following consultation and agreement with NRW.

1.3 Data Sources

1.3.1 The data sets and resources listed below, as provided by NRW and Natural England, have been used to inform this assessment:

a) Cycle 2 River Basin Management Plan, Western Wales (NRW, 2015);

b) RBMP Cycle 2 water body classification data for the WFD waterbodies listed in Table 4[3];

c) Lle Geo Portal: http://lle.gov.wales/map;

d) NRW's 'Water Watch Wales' website: http://waterwatchwales.naturalresourceswales.gov.uk/en/; and

e) Natural England 'MAGIC' website: http://www.magic.gov.uk.

1.3.2 No WFD monitoring data is available for any of the watercourses directly crossed or affected by the scheme.

[1] OGN072: Guidance for assessing activities and project for compliance with the Water Framework Directive, May 2017.
[2] Advice Note Eighteen: The Water Framework Directive. The Planning Inspectorate, June 2017.
[3] A detailed breakdown of the status of individual quality elements was provided by NRW via email on 2nd August 2017.

2 Scheme Design

2.1.1 The section describes the elements of the scheme design that are relevant to the WFD compliance assessment.

2.2 Carriageway drainage

2.2.1 The design philosophy of the carriageway drainage includes mitigation measures to ensure that flood risk in not increased in the vicinity of the scheme and elsewhere, to ensure that soluble and suspended pollutants in carriageway runoff are reduced to acceptable levels prior to discharge to groundwater or local watercourses.

2.2.2 Where possible, highway runoff would be infiltrated into the ground using attenuation/ infiltration basins. Where infiltration is not an option, the proposed surface water discharge would be attenuated to the Greenfield Runoff Rate. Attenuation is to be provided by basins, sized to accommodate the 1 in 100-year event with an allowance for climate change.

2.2.3 As part of the Environmental Statement (Chapter 7: Road Drainage and the Water Environment), assessments of the potential impacts to surface or ground waters resulting from routine runoff from the carriageway, accidental spillage (during construction and operation) and Ground Water Dependant Terrestrial Ecosystems (GWDTEs) have been carried out. These assessments have followed the methodologies provided in Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 10: LA 113 Road Drainage and the Water Environment (August 2019), subsequently referred to in the report as LA 113. Detailed results are provided within Appendix C.

2.3 Physical modifications

2.3.1 The drainage design of the scheme directs runoff from the carriageway to five attenuation basins prior to discharge into surface waters via four new outfalls. The five attenuation basins in the scheme design at the point of writing have been assessed; labelled Attenuation Basins A to E. Wherever possible, runoff will be allowed to infiltrate to groundwater ahead of discharge to surface waters. New structures introduced to surface waters as a result of the scheme include six culverts and the shortening of an existing watercourse, listed in Table

2. None of the watercourses where new structures are proposed are classified as main rivers.

2.3.2 The scale of these modifications is to be confirmed during detailed design.

2.3.3 The locations of the receiving waterbodies, outfalls and culverts are listed in Table 1 and Table 2 respectively. These features are also illustrated in Volume 2, Figure 7.3. Water features which will not receive runoff are scoped out of this assessment.

Table 1 Discharge locations used for HEWRAT Assessments

Outfall	Chainage	Receiving Watercourse
Basin A	0+000	Unnamed tributary of Narberth Brook 3
Basin B	1+350	Unnamed Tributary of Marlais 3
Basin C	0+320	Unnamed tributary of Narberth Brook 1
Basin D	0+730	Unnamed Tributary of Marlais 4
Basin E	1+780	Unnamed Tributary of Marlais 1

Table 2 Proposed physical modifications to surface waters

Culvert ID (Figure 7.3)	Approximate Culvert Chainage	Watercourse	Solution
Culvert 1	0+000	Unnamed tributary of Narbeth Brook 2	Proposed 1.2m culvert to existing watercourse
Culvert 2	0+450	Unnamed tributary of Narbeth Brook 1	Proposed culvert 1.2m dia..
Culvert 3	0+460 (side road)	Unnamed tributary of Narbeth Brook 1	Proposed culvert 1.2m dia.
Culvert 4	0+860	Unnamed tributary of Afon Marlais 4	Proposed culvert 1.2m dia.
Attenuation Basin B	1+350	Unnamed Tributary of Afon Marlais 3	Attenuation basin to remove upper 60m of watercourse
Culvert 5	1+390	Unnamed tributary of Afon Marlais 2	Proposed combined culvert and farm access
Culvert 6	1+690	Unnamed tributary of Afon Marlais 1	Proposed culvert 1.2m dia.

2.4 Cuttings and embankments

2.4.1 The scheme follows a ridgeline for much of its length and therefore does not have any major cuttings or embankments. Table 3 details significant areas of cutting or embankment along the scheme.

Table 3 Proposed areas of significant cutting and embankments

Start Chainage (approx.)	End Chainage (approx.)	Location	Feature
0+000	0+405	East of Sodston Lodge	Cutting
0+405	0+500	West of Redstone Cross Junction (Crossing of Narberth Brook tributary)	Embankment
0+500	0+730	South of Redstone Cross Junction	Cutting
0+730	1+485	South of Blackmoor Hill Farm	Embankment
1+485	1+779	West of Penblewin Roundabaout	Cutting

3 WFD Baseline

3.1 Overview

3.1.1 Three WFD river water bodies and two groundwater bodies would be crossed by the scheme (Table 4). The extents of these WFD surface and groundwater bodies are shown in Volume 2 Figure 7.2 and 7.3 respectively.

3.1.2 The potential effects of the scheme are confined to localised changes in minor watercourses and groundwater. When considered against the scale of WFD waterbodies, these potential effects do not extend beyond the boundaries of the above waterbodies and therefore no other WFD waterbodies are included in this assessment.

3.1.3 The following sections describe the water bodies in greater detail.

Table 4 WFD waterbodies within the scheme area

Waterbody Name	ID	Waterbody Type	River Basin District	Management Catchment	Area (km^2)
Narbeth Brook - headwaters to conf with E. Cleddau	GB11006 1030670	River	Western Wales	Carmarthen Bay and the Gower	17.89
Longford Brook - HW to conf with E. Cleddau	GB11006 1030680				26.63
Marlais - headwaters to confluence with Taf	GB11006 0029240			Cleddau and Pembrokeshire Coastal Rivers	14.54
Tywi, Taf and Gwendraeths	GB41002 G200500	Groundwater		N/A	1947.43
Cleddau and Pembrokeshire	GB41002 G200400				1115.63

3.2 WFD classifications

3.2.1 The current status, failing elements, and reasons for failure for Cycle 2 (2015-2021) of the WFD waterbodies, included in the study area, are outlined in Table 5.

Table 5 Summary of WFD water bodies[4]

WFD Waterbody	Narberth Brook	Longford Brook - HW to confluence with E. Cleddau	Marlais - headwaters to confluence with Taf	Tywi, Taf and Gwendraeths	Cleddau and Pembrokeshire
ID	GB110061030660	GB110061030680	GB110060029240	GB41002G200500	GB41002G200400
Type of Waterbody	River	River	River	Groundwater	Groundwater
Management Catchment	Cleddau and Pembrokeshire Coastal Rivers	Cleddau and Pembrokeshire Coastal Rivers	Carmarthen Bay and the Gower	WA South West	WA South West
Area (km^2)	17.89	14.54	26.63	1,947.43	1,115.63
HMWB/AWB?	No	No	No	No	No
Overall Status	Moderate	Moderate	Moderate	Poor	Poor
Objective	NA	Good by 2021	NA	Poor by 2015	Good by 2021
Chemical Status	Good	Good	Good	Poor	Poor
Ecological Status (river), Quantitative Status (groundwater)	Moderate	Moderate	Moderate	Good	Good

[44] Information relevant for Cycle 2 of the WFD (2015-2021) and obtained from http://waterwatchwales.naturalresourceswales.gov.uk/en/ (Accessed on 13th December 2019).

WFD Waterbody	Narberth Brook	Longford Brook - HW to confluence with E. Cleddau	Marlais - headwaters to confluence with Taf	Tywi, Taf and Gwendraeths	Cleddau and Pembrokeshire
Driver of failure to achieve Good status	Macrophytes and Phytobenthos Combined	Fish, Macrophytes and Phytobenthos Combined	Ammonia (Phys-Chem)	Chemical Dependent Surface Water Body Status	Chemical GWDTEs test
Reason for not achieving Good status	Unknown (Pending Investigation)	Ammonia (Fish) Unknown (pending investigation)	Unknown (Pending Investigation)	Point source pollution from abandoned mines.	Unknown
Other (including Mitigation Measures)	Within Cleddau Rivers SAC	Reduce diffuse source pollution at source by controlling or managing diffuse source inputs. Cleddau Rivers SAC at downstream end of catchment. To be targeted by NRW to achievements in status by 2021			

3.3 'Narbeth Brook – headwaters to conf with E. Cleddau' (GB110061030670)

3.3.1 The 'Narbeth Brook – headwaters to conf with E. Cleddau' (GB110061030670) river water body currently has an overall status of moderate. This waterbody does not currently have an objective.

3.3.2 Watercourses within this catchment that have the potential to be impacted by the scheme include three unnamed tributaries of Narbeth Brook.

3.3.3 As shown in Volume 2, Figure 7.1 and the drainage figure, the unnamed tributaries of Narberth Brook 1 and 2 are culverted at chainage 0+000 and 0+450, both crossings are close to the source of the respective watercourses. Both watercourses are tributaries of the unnamed tributary of Narberth Brook 3, with outfall structures to be constructed into this watercourse approximately 1.9km upstream of Narberth Brook.

3.4 'Longford Brook - HW to conf with E. Cleddau' (GB110061030680)

3.4.1 The 'Longford Brook - HW to conf with E. Cleddau' (GB110061030680) river water body currently has an overall status of moderate due to fish. It has an objective to achieve good overall status by 2021.

3.4.2 Watercourses within this catchment that have the potential to be impacted by the scheme include 4 unnamed tributaries of Longford Brook.

3.4.3 A number of these tributaries have heads within the 500m study area.

3.4.4 The head of the closest watercourse is approximately 175m from the scheme. Each unnamed tributary of Longford Brook follows field boundaries to the north of the scheme and flow northwards to join the Longford Brook main river, 1km to the north west of the scheme. A number of the watercourses flow through the area of woodland between the study area and Longford Brook.

3.5 'Marlais - headwaters to confluence with Taf' (GB110060029240)

3.5.1 The 'Marlais - headwaters to confluence with Taf' (GB110060029240) river water body currently has an overall status of moderate due to zinc and cadmium, although this classification is under investigation due to suspect data. It has an objective to achieve good overall status by 2021.

3.5.2 Watercourses within this catchment which have the potential to be impacted by the scheme includes unnamed tributaries to the Afon Marlais 1-4, shown in Volume 2, Figure 7.1.

Unnamed tributary of Afon Marlais 1

3.5.3 On site visit, this watercourse was observed as a formed, dry channel. It is considered this watercourse is a drainage ditch. As shown in the Volume 2, Figure 7.1, the scheme crosses this watercourse approximately 60m downstream from the head of the stream, directly south of the existing A40, from where it flows southwards.

Unnamed tributary of Afon Marlais 2

3.5.4 The proposed crossing is close to the source of the watercourse, approximately 220m downstream of the head. The watercourse follows dense vegetation cover along field margins.

Unnamed tributary of Afon Marlais 3

3.5.5 The watercourse rises in the middle of a field, joins a hedgerow approximately 140m downstream and then continues to follow field margins. It is considered this watercourse is a drainage ditch. As shown on Volume 2, Figure 7.1, the upper section of this watercourse will be lost due to the location of Attenuation Basin B.

Unnamed tributary of Afon Marlais 4

3.5.6 This watercourse rises within the woodland area to the north of the scheme, it follows the northern field boundary, is culverted through the scheme at 0+800 (exact location to be confirmed by topographic survey) and joins a number of other unnamed tributaries to the south of the scheme.

3.6 'Tywi, Taf and Gwendraeths' (GB41002G200500)

3.6.1 The 'Tywi, Taf and Gwendraeths' (GB41002G200500) groundwater body currently has an overall status of moderate due to zinc and cadmium, although this classification is under investigation due to suspect data. It has an objective to achieve good overall status by 2021.

3.7 'Cleddau and Pembrokeshire' (GB41002G200400)

3.7.1 The 'Cleddau and Pembrokeshire' (GB41002G200400) groundwater body currently has an overall status of poor as the result of poor chemical status resulting from the assessment of the status of Ground Water Dependant Terrestrial Ecosystems (GWDTE) within the waterbody.

3.8 Protected Areas & Species

3.8.1 Under the WFD, 'Protected Areas' are defined as areas requiring special protection because of their sensitivity to pollution or due to their particular economic, social or environmental importance. These areas are waterbodies or parts of them:

a) used for the abstraction of water intended for human consumption (Drinking Water Protected Area);

b) supporting economically significant shellfish or freshwater fish stocks (Freshwater Fish Water; Shellfish Water);

c) where a large number of people are expected to bathe (Bathing Water);

d) supporting habitats or species of international biodiversity conservation importance (Special Area of Conservation, Special Protection Area);

e) sensitive to nutrient enrichment (Nitrate Vulnerable Zone; UWWTD Sensitive Zone).

3.8.2 The specific environmental designations, measures and actions for these protected areas have been established under previous European Directives, which set out the requirements to ensure the protection of the area's water environment or protection of wildlife that is directly dependant on that water environment. Where a WFD waterbody falls within or forms all or part of one of these designated predicted areas,

the waterbody is subject to additional environmental objectives (and associated monitoring regimes, risk assessments, and regulations) in accordance with the relevant, previous Directive(s).

3.8.3 The scheme is not located within any designated areas. However, Longford Brook, Narberth Brook and their tributaries are upstream of the 'Cleddau Rivers' Special Area of Conservation (SAC; Site Code: UK0030074). The proposed scheme crossing of a tributary of Narbeth Brook is approximately 1.9km upstream of the SAC.

3.8.4 The SAC is designated due to the following[5]:

Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site:

a) watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batracion* vegetation
b) active raised bogs; and
c) alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*.

Annex II species that are a primary reason for selection of this site:

a) brook lamprey *Lampetra planeri*;
b) river lamprey *Lampetra fluviatilis*;
c) bullhead *Cottus gobio*; and
d) European otter *Lutra lutra*.

Annex II species present as a qualifying feature, but not a primary reason for site selection:

a) sea lamprey Petromyzon *marinus*.

3.8.5 Ecology surveys for this scheme in 2019 identified field signs of otter on two watercourses within the study area. Evidence of otter was also observed during the 2016 baseline surveys for the adjacent A40 Llanddewi Velfrey to Penblewin Improvements scheme. Desk and walkover surveys have identified records of invasive species (*Cotoneaster* spp and Rhododendron) in the vicinity of the scheme.

3.8.6 Further details on biodiversity relating to the study area are provided in Nature Conservation (Volume 1, ES Chapter 8).

[5] EU Habitats Directive: Directive 92/43/EEC of the European Parliament and of the Council; of 21 May 1992; *on the Conservation of natural habitats and of wild fauna and flora.*

4 Assessment Methodology

4.1.1 The assessment comprises of three stages, as recommended by NRW[1], to assess the potential for each proposed activity (individually and in combination) to impact on individual (or multiple) WFD quality elements:

a) Screening - exclude any activities that do not need to go through the scoping or detailed assessment stages;

b) Scoping - identify the quality elements that are potentially at risk from the proposed activity and need further detailed assessment; and

c) Detailed Assessment - consider the potential impacts of an activity on bodies of surface and ground water, identify ways to avoid or minimise impacts, and identify if an activity may prevent the water body achieving good status or cause deterioration.

4.1.2 NRW guidance[1] states that for a project or activity to be compliant with the WFD, the assessment should demonstrate that:

a) there is no risk of it causing a deterioration of the status of any element; in addition, for groundwater we will limit or prevent the input of pollutants;

b) there is no risk of it preventing WFD Protected Areas from achieving their objectives;

c) it will not jeopardise any water body from achieving good status/potential;

d) it will contribute to the protection, enhancement and restoration of water bodies.

4.1.3 The WFD is primarily concerned with non-temporary deterioration. Here, temporary impacts are defined as *less than three years*, with impacts not considered to constitute deterioration of status of the water body if the water body:

a) is only impacted for a short time period (less than three years);

b) recovers within a short time period (less than three years); and/or

c) recovers without the need for any restoration measures.

4.1.4 Temporary works where impacts have the potential to be longer lasting (i.e. longer than three years) are considered in the assessment.

4.1 Assumptions

4.1.1 Watercourses that are crossed by the scheme which are not officially designated as WFD water bodies by NRW are included in the assessment. It is assumed that these water bodies have the same status objectives as the designated water body into which they flow. However, the measures proposed to mitigate any adverse impacts on these water bodies aims to be appropriate to their local context.

5 Screening

5.1.1 Activities that may result in an impact on WFD quality elements may take place during construction and/or operation of the Scheme. Table 6 details the expected activities, whether they have been screened in/out of further assessment, along with an explanation for the screening decision. Where activities have been screened in to the assessment, they are considered against WFD quality elements in the scoping stage.

Table 6 Screening of proposed activities against WFD objectives

Proposed Activity	Screen In/Out	Explanation
Construction Activities		
Temporary modification of watercourses during instream works	Out	Measures considered to be best practice will be adopted during construction to ensure that temporary impacts to watercourse morphology are minimised and are restored following construction. Standard construction practices are detailed in the Pre-CEMP with additional mitigation measures included in Chapter 7: Road Drainage and the Water Environment of the Environmental Statement. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Temporary discharge of site runoff to surface waters	Out	Measures considered to be best practice will be adopted during construction to ensure that runoff discharged from the site is of acceptable quality and is discharged in a manner that does not impact upon geomorphology or hydrology of local watercourse. Standard construction practices are detailed in the Pre-CEMP with additional mitigation measures included in Chapter 7: Road Drainage and the Water Environment of the Environmental Statement. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.

Proposed Activity	Screen In/Out	Explanation
Temporary discharge of site runoff to groundwater	Out	Measures considered to be best practice will be adopted during construction to ensure that where site runoff is allowed to infiltrate to groundwater it is of acceptable quality and is discharged in a manner that does not impact upon other users of the groundwater. Standard construction practices are detailed in the Pre-CEMP with additional mitigation measures included in Chapter 7: Road Drainage and the Water Environment of the Environmental Statement. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Changes in groundwater levels and flows as a result of localised dewatering during construction of cuttings	In	Dewatering during construction required for cuttings along the scheme is likely to result in a local depression of groundwater levels which has the potential to cause the following effects: • Transport of existing contamination as a result of increased groundwater flow in the vicinity of any dewatering; and • Impacts upon surface features that are reliant upon groundwater levels (e.g. marshes, ponds, springs). **Although the level of dewatering will be temporary it has the potential to cause longer lasting impacts to WFD quality elements.**
Accidental spillage of pollutants	Out	Measures considered to be best practice, which are detailed in the Pre-CEMP, will be adopted during construction to ensure that if an accidental spillage occurs it will be contained and disposed of appropriately. With these measures in place no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity.
Operational Activities		

Proposed Activity	Screen In/Out	Explanation
Discharge of routine carriageway runoff to groundwater	Out	Infiltration to groundwater is the preferred method of drainage for the scheme[6]. Filter drains will be installed in areas of cutting and attenuation basins will allow for water to infiltrate to the ground in preference to discharge to local watercourses where possible. An assessment of the potential effects of discharging carriageway runoff to groundwater, undertaken as part of the Environmental Statement (Chapter 7: Road Drainage and Water Environment), indicated a medium risk to groundwater as a result of the scheme. Due to the mitigation measures incorporated into design attenuating pollutants sufficiently below the Environmental Quality Standards (EQS), it is considered the risk of pollution entering groundwater is removed. See Method C assessment in Appendix C3. No permanent impacts on the current status or status objectives of WFD groundwater quality elements are expected as a result of this activity and therefore this activity is scoped out of the assessment.
Discharge of routine carriageway runoff to surface waters	Out	Runoff from the carriageway will pass through an attenuation basin (see Section 2.2) prior to its discharge to local watercourses. Where possible, runoff will be infiltrated to groundwater in preference to discharge to surface watercourses. An assessment of the potential effect of discharging carriageway runoff to surface waters, undertaken has been part of the Environmental Statement (Chapter 7: Road Drainage and Water Environment). This indicated that, following the addition of a forebay at attenuation basin B, there is a negligible risk to water quality of all receiving surface watercourses. This HEWRAT assessment followed the approach detailed in LA 113. Detailed results are provided within Appendix C1. No permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity and therefore this activity is scoped out of the assessment.
Accidental spillage to ground or surface waters	Out	An assessment of the risk of accidental spillage to surface or ground waters has been undertaken as part of the Environmental Statement (Chapter 7: Road Drainage and Water

[6] Drainage strategy – Volume 3, Appendix 7.2

Proposed Activity	Screen In/Out	Explanation
		Environment). Details are provided within Appendix C4. The assessment followed the approach detailed in Appendix D of LA 113 and indicated a negligible risk of accidental spillage. No permanent impacts on the current status or status objectives of WFD quality elements are therefore expected as a result of this activity and this activity is scoped out of the assessment.
Changes in groundwater levels as a result of new cuttings & their associated drainage	In	The new cuttings included in the scheme design (Table 3) will cause local changes to groundwater drainage which may result in changes to groundwater levels. **There is potential for this activity to result in impacts to WFD quality elements.**
Changes in surface water flow regimes as a result of new cuttings, embankments or road drainage	In	The new cuttings and embankments included in the scheme design (Table 3) will cause local changes to groundwater drainage which are likely to result in changes to the flow regimes of minor watercourses in the scheme area. The significant areas of cutting and embankment for the scheme are located in the 'Marlais – headwaters to confluence with Taf' (GB110060036283) water body and in a tributary of 'Narberth Brook – headwaters to confluence with E. Cleddau' (GB110061030670). The Longford Brook waterbody is therefore screened out of this activity. **There is potential for this activity to result in impacts to WFD quality elements.**
Physical modification of watercourses due to new structures (e.g. culverts or headwalls)	In	The new structures included in the scheme design (Table 2) have the potential to cause local reductions in habitat availability. Culverts can act as barriers to fish passage and sediment transport and any new structure can disturb flow regimes and result in localised erosion. All three WFD surface water bodies are screened into this activity. **There is potential for this activity to result in impacts to WFD quality elements.**
Shortening of Unnamed Tributary of Afon Marlais 3	In	The direct loss of a section of this watercourse has the potential to decrease the value of the watercourse through decreasing habitat area and changing the hydromorphological processes of the affected watercourse. **There is potential for this activity to result in impacts to WFD quality elements.**

6 Assessment

6.1 Potential Risks

Construction

6.1.1 The screening assessment has identified the following construction activity as having potential risks to WFD quality elements:

a) Changes in groundwater levels and flows as a result of localised dewatering during construction of cuttings.

Operation

6.1.2 The screening assessment has identified the following operational activities as having potential risks to WFD quality elements:

a) Changes in groundwater levels as a result of new cuttings and their associated drainage;

b) Changes to surface water flow regimes as a result of new cuttings; embankments or road drainage;

c) Physical modifications of watercourses due to new structures; and

d) Shortening of Unnamed Tributary of Narberth Brook 1.

6.2 Construction

6.2.1 The assessment of the potential impacts of dewatering is presented in Appendix 7.4. This identified a potential impact on the following features:

Table 7 Identified features potentially impacted by construction of cuttings

ID	Feature type	Approximate distance to cutting causing potential impact	Approximate ground elevation, mOD	Base flow affected	Direct surface water catchment
GW7	Headwaters of unnamed tributary of Longford Brook;	Cutting 3 130m N	93	GW	Longford Brook
GW14	Headwaters of unnamed tributary of Narberth Brook	Cutting 1 40m N	96	GW/ SW run-off	Narberth Brook
E	Pond	Cutting 1 130m S	101	GW	

6.2.2 The assessment of effects on the identified GWDTE woodland being directly lost due to the footprint of the scheme is discussed within the Nature Conservation chapter (Volume 1, ES Chapter 8). No impact on groundwater levels and flows feeding into that feature has been identified.

6.2.3 The potential impact on the identified features may result in reduced flows within the watercourses and potentially lower level of water within the pond. These are considered to have a minor adverse impact on the identified features. It is therefore unlikely that this would result in a degradation in the status of quality elements of the WFD groundwater body.

6.3 Operation

Changes in groundwater levels as a result of new cuttings & their associated drainage

6.3.1 The impact on groundwater levels as a result of the cuttings and highway drainage is defined within Volume 3, Appendix 7.4. The assessment does not differ from the construction scenario as presented in Construction Effects above, such that it is unlikely that this activity would result in a degradation in the status of quality elements of the WFD groundwater body.

Changes in surface water flow regimes as a result of new cuttings, embankments or road drainage

6.3.2 Construction of the cuttings has a potential to locally impact groundwater levels, gradient and flow rates, which may in turn impact upon surface water flows. The initial assessments of the potential impacts on groundwater dependent features identified three surface water features where there is a potential for the cuttings to impact groundwater flows and levels. These are summarised below.

6.3.3 Impacts would be minor and localised to headwaters. It is therefore unlikely that this would result in a degradation in the status of quality elements of the WFD surface water bodies.

Table 8 Identified features potentially impacted by construction of cuttings

ID	Feature type	Approximate distance to cutting causing potential impact	Approximate ground elevation, mOD	Base flow affected	Direct surface water catchment
GW7	Headwaters of unnamed tributary of Longford Brook;	Cutting 3 130m N	93	GW	Longford Brook
GW14	Headwaters of unnamed tributary of Narberth Brook	Cutting 1 40m N	96	GW/ SW run-off	Narberth Brook
E	Pond	Cutting 1 130m S	101	GW	

Physical modification of watercourses due to new structures

6.3.4 To address the potential impacts of new structures such as outfalls and culverts, mitigations should be included in the detailed design of the scheme. The mitigation measures listed below are considered best practice for the design of outfalls and culverts.

6.3.5 The design of any new or extended culverts should ensure that:

a) The base of the culvert is set below the existing bed of the watercourse. This will help to retain habitat connectivity either side of the culvert and promote continued sediment transport downstream;

b) The culvert width is greater than that of the existing watercourse, such that it does not constrict the watercourse at the entrance or exit to the structure; and

c) Suitable scour protection is installed at the culvert inlet and outlet, making use of bioengineering methods and products where practicable.

6.3.6 The design of any new outfalls should ensure that:

a) The headwall structure is set back from or flush with the channel profile and does not protrude into the channel;

b) The outfall is angled to direct flow at an angle no greater than 60 degrees from the existing flow direction in the watercourse; and

c) Any scour protection surrounding the outfall headwall uses bioengineering methods wherever practicable to maximise habitat potential.

6.3.7 The design and construction supervision of these mitigation measures should be led by a qualified geomorphologist.

Shortening of Unnamed Tributary of Afon Marlais 3

6.3.8 The watercourse is marked as ‘drain’ on OS mapping. Site inspection of the field containing the proposed Attenuation Basin B and Afon Marlais 3 shows it to be waterlogged with a vegetated strip of land alongside a tree line in the marked watercourse location. It is considered the marked watercourse location has no greater ecological or hydrological value to the downstream watercourse than the surrounding field. Therefore, with the drainage strategy incorporating the catchment requirements, the direct loss of the unnamed tributary of Afon Marlais 3 habitat area due to the location of Attenuation Basin B is not considered to present the potential to impact on the overall WFD status of the Narberth Brook.

Photograph 1 Unnamed Tributary of Narberth Brook 1. OS marked ‘drain’ is along the treeline on the right of the photo. Photo taken looking east.

6.3.9 No permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of this activity and therefore this activity is scoped out of the assessment.

6.3.10 Provided that these mitigation measures are included then given the minor nature of the watercourses effected, no permanent impacts on the current status or status objectives of WFD quality elements are expected as a result of the proposed in-channel structures.

7 Conclusions

7.1.1 This WFD assessment has been conducted as part of the Environmental Statement for the scheme and should be read in conjunction with Chapter 7: Road Drainage and the Water Environment.

7.1.2 The assessment identified one construction and three operational activities that had potential risks on WFD quality elements. However, it is considered that following the implementation of a CEMP, the drainage design and best practice design of outfalls and culverts, there would be no permanent impacts on the current status or status objectives of WFD quality elements.

7.1.3 The assessment identified the new structures (culverts and outfalls) required for the scheme drainage, as having the potential to impact upon WFD quality elements and objectives. Mitigation measures have been proposed, to be incorporated in the detailed design of the scheme, to ensure that these structures do not impact upon the status or the future objectives of any WFD quality elements.

7.1.4 It is recommended that NRW is consulted on the outcomes of this assessment prior to detailed design of the scheme.

7.1.5 This assessment should be considered as a ‘live’ document that should be updated if NRW update or provide additional WFD baseline data for the relevant water bodies; and/or significant changes to the nature, alignment, scale or construction methods of the Scheme are made.

Appendix A

Background to the WFD

A1 Overview of the WFD

A1.1 Aims

The Water Framework Directive (WFD) aims to protect and enhance the quality of the water environment across all European Union (EU) member states. It takes a holistic approach to the sustainable management of water by considering the interactions between surface water, groundwater and water-dependent ecosystems.

Under the WFD, 'water bodies' are the basic management units and are defined as all or part of a river system or aquifer. These water bodies form part of a larger 'River Basin District' (RBD), for which 'River Basin Management Plans' (RBMP) are developed by EU member states and environmental objectives are set. These RBMP are produced every six years, in accordance with the river basin management planning cycle.

The WFD requires all EU member states to classify the current condition or 'status or potential' of surface water and groundwater bodies and to set a series of objectives for maintaining or improving conditions so that water bodies maintain or reach 'good status or potential'.

A1.2 WFD requirements for new developments

To ensure compliance with the WFD, decision makers must consider whether proposals for new developments have the potential to:

- cause a deterioration of a water body from its current status or potential;
- prevent future attainment of good status or potential where not already achieved;
- impact on protected or priority species and habitats; and/or
- provide opportunities to improve the water environment.

A1.3 Legislative Context

A1.3.1 EU Water Framework Directive

The Water Framework Directive (WFD)[7] has been in force since 2000 and is currently the largest and most influential piece of European Union (EU) legislation relating to the water environment. The Directive was transposed into UK law by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017[8]. NRW is the competent authority responsible for delivering the Directive in Wales.

The Directive requires that Environmental Objectives be set for all surface and groundwater water bodies to enable them to achieve 'Good Ecological Status'

[7] EU Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council; of 23 October 2000; Establishing a framework for Community action in the field of water policy.
[8] Statutory Instruments, 2017 No.407, The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017

(GES) – or 'Good Ecological Potential' (GEP) for Heavily Modified and Artificial Water Bodies – by a defined date. These Environmental Objectives are to:

- prevent deterioration in the status of aquatic ecosystems, protect them and improve the ecological condition of waters;
- aim to achieve at least 'Good' status for all water bodies by 2021. Where this is not possible and subject to the criteria set out in the Directive, aim to achieve Good status by 2027;
- meet the requirements of WFD Protected Areas;
- promote sustainable use of water as a natural resource;
- conserve habitats and species that depend directly on water;
- progressively reduce or phase out the release of individual pollutants or groups of pollutants that present a significant threat to the aquatic environment;
- progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants; and
- contribute to mitigating the effects of floods and droughts.

The framework for delivering the Directive is through the definition of River Basin Districts (RBDs) and the River Basin Management Plans (RBMPs)[9]. The current and objective 'Overall Status', 'Ecological Status/Potential' and 'Chemical Status' classifications of each surface water body is set out in the relevant RBMP. Background information regarding the water body status classification process that applies under the WFD is provided in Appendix B.

All new (and currently on-going) activities in the water environment need to consider the requirements of the WFD to ensure that no changes occur that:

a. cause a deterioration of current status of a water body; and
b. prevent the achievement of the future status objectives of a water body (i.e. GES or GEP by 2021 or 2027).

This principle is now integrated into the project/option appraisal process, as well as the EIA requirements for proposed schemes/activities under the town and country planning system.

A1.3.2 Water Framework Directive Directions (England & Wales) 2015

Under the WFD, a range of environmental standards and condition limits are applied in order to define water body status and the set status objectives via the RBMP process to support "healthy" aquatic life. For instance, standards are set for the composition of biological communities, the physicochemical water quality parameters, the concentration of pollutants, and the level of flows in rivers. These standards inform NRW on the implementation of the RBMP process, including the identification of measures required to support the achievement of GES/GEP

[9] See: https://www.gov.uk/government/collections/river-basin-management-plans

objectives, as well as underpinning efforts to protect the water environment by helping to regulate activities that could cause adverse impacts.

A1.4 Cycle 2 River Basin Management Plans

The ‘Cycle 2’ RBMPs were released in 2015 and are an update to the ‘Cycle 1’ plans originally published in 2009. This study has been conducted based on the 2015 Cycle 2 RBMP water body status classification data. This data comprises the latest information that is currently available regarding the baseline condition of WFD water bodies in the UK.

Appendix B

Determination of WFD Status

B1 Determination of WFD status

B1.1 Introduction

Surface water bodies and Groundwater bodies are defined within WFD legislation. There are three types of surface water body, as follows:

- Natural water bodies;
- Heavily Modified Water Bodies (HMWBs);
- Artificial Water Bodies (AWBs).

The overall status of natural surface water bodies is determined on the basis of their Ecological Status and Chemical Status (see **Figure B2.1** below). The overall status of Heavily Modified and Artificial Water Bodies is classified based on their Ecological Potential and Chemical Status. The overall status of groundwater bodies is determined on the basis of their Quantitative Status and Chemical Status.

Groundwater bodies are defined within WFD legislation as Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU) and their status is determined on the basis of quantitative and chemical sub-elements.

The means by which these determinations are made for both surface water and ground water bodies is described below.

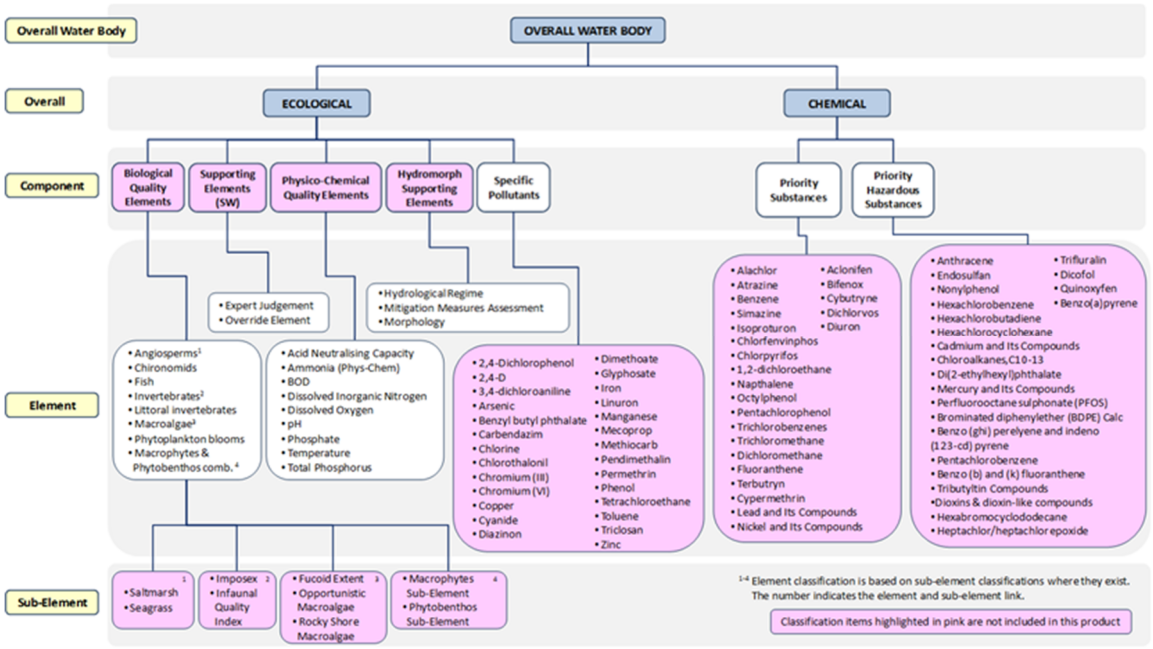

Figure B2.1: Overview of the Ecological Status and Chemical Status classification components for natural surface water bodies [EA, 2015]

B1.2 Determination of the Ecological Status of natural surface water bodies

B1.2.1 Ecological Status

Ecological Status is defined by the overall quality of the structure and functioning of aquatic ecosystems associated with surface waters, i.e. the condition of the watercourse. This is assigned on a scale of High, Good, Moderate, Poor or Bad, and on the basis of four classification elements or 'tests', as follows:

Biological - This test is designed to assess the status indicated by a Biological Quality Element such as fish, invertebrates, macrophytes or phytobenthos (diatoms). The Biological Quality Elements can influence an overall water body status from Bad through to High. It is also important to note that the presence of invasive species prevents a water body from achieving high status when all other elements attain high.

Physicochemical - This test is designed to assess the status indicated by Physicochemical Quality Elements such as dissolved oxygen, phosphorus and ammonia, against environmental standards. The Physicochemical Quality Elements can only influence an overall water body status from Moderate through to High.

Specific pollutants - This test is designed to assess compliance with environmental standards for concentrations of Specific Pollutants, such as zinc, cypermethrin or arsenic. As with the physicochemical test, the specific pollutant assessment can only influence an overall water body status from Moderate through to High.

Hydromorphology - For natural surface water bodies this test is undertaken by the Environment Agency during classification when the biological and physicochemical tests indicate that a water body may be of High status. It specifically assesses Hydromorphological Quality Elements such as water flow, sediment composition and movement, continuity, and structure of the habitat against reference or 'largely undisturbed' conditions. If the Hydromorphological Quality Elements do not support High Ecological Status, then the status of the water body is limited to Good overall status. Hydromorphological assessments are used to determine 'High' overall Ecological Status only, and are not be used to drive a water body status class below Good. The 'does not support good' classification should be reported for the purposes of identifying water bodies which fail the flow test.

The worst-case classification is assigned as the overall surface water body status, in a 'one-out all-out' system. This system is summarised in **Figure B2.2**.

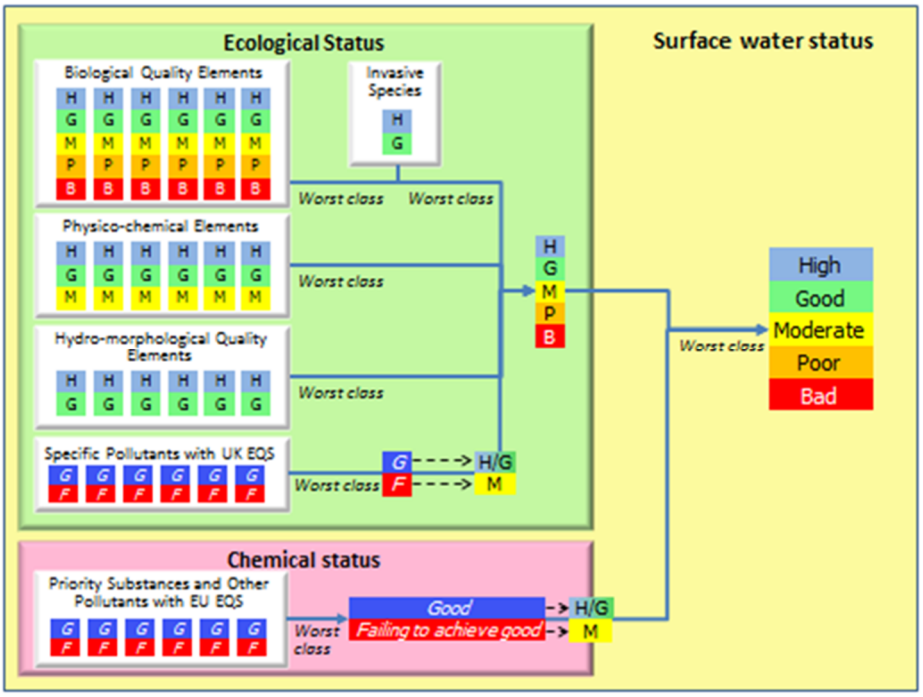

Figure B2.2: WFD classification elements for surface water body status. [Source: Environment Agency Rules for Assessing Surface Water Body Status and Potential (2015)]

B1.2.2 Chemical Status

Chemical Status is defined by compliance with environmental standards for chemicals that are Priority Substances and/or Priority Hazardous Substances, in accordance with the Environmental Quality Standards Directive (2008/105/EC). This is assigned on a scale of Good or Fail.

Surface water bodies are only monitored for Priority Substances where there are known discharges of these pollutants; otherwise surface water bodies are reported as being of Good Chemical Status.

B1.3 Determination of Ecological Potential for Heavily Modified (and Artificial) Water Bodies

Ecological Potential is assigned to Artificial Water Bodies (AWB) (such as reservoirs and canals), or natural water bodies which, as a result of physical alterations by human activity, are substantially changed in character. The latter are termed Heavily Modified Water Bodies (HMWB). The term 'Ecological Potential' is used to classify AWBs and HMWBs as it may be impossible for these water bodies to achieve Good Ecological Status (GES) because of their creation or modification for a specific use, such as navigation, water supply or flood protection. The Ecological Potential of an AWB or HMWB represents the degree to which the quality of the water body approaches the optimum condition it could achieve given its artificial or heavily modified state.

AWB and HMWBs are subject to an additional set of rules that need to be implemented prior to running the one-out-all-out process. These rules determine which Biological Quality Elements should be used in the water body Ecological

Potential classification. Under normal circumstances, AWB and HMWBs are classified according to an assessment of Mitigation Measures, which defines Good Ecological Potential in water bodies where all applicable mitigation is in place, and Moderate Ecological Potential in water bodies where some or all relevant mitigation is missing. However, to prevent AWB and HMWBs being incorrectly classified as good potential in situations where all mitigation is in place, but other pressures are causing an impact (e.g. nutrient enrichment or pollution from toxic substances), the methodology adopted in the UK additionally considers biological indicators providing they are not sensitive to the heavily modified nature of the water body.

AWB and HMWB hydromorphological elements are assessed using a three-stage process, firstly looking at flow, then Mitigation Measures and Biological Quality Elements.

Flow conditions are assessed initially on a fail or pass basis to determine which of the Biological and Physicochemical Quality Elements should be used in the classification of Ecological Potential.

Where the flow conditions are unaffected by the physical modification (flow conditions pass), the water body potential is determined by the worst of either the Mitigation Measures assessment, or any element that is not sensitive to the modified nature of the water body.

Where the flow conditions are significantly impacted by the physical modification (flow conditions fail), the water body potential is determined by the worst of any of the Mitigation Measures assessments or the assessment of Biological Quality Elements, Physicochemical Quality Elements or Specific Pollutants.

Where a water body is designated as Artificial or Heavily Modified for water resources usage, either solely or jointly with other uses, the flow condition is assumed to be good (pass).

B1.4 Determination of the Ecological Status of groundwater bodies

Under the WFD, groundwater body status is classified on the basis of Quantitative Status and Chemical Status. The groundwater bodies are separated into Groundwater Management Units (GWMU) and Water Resource Management Units (WRMU). GWMU are sub-divisions of the groundwater to aid the resource assessment process. WRMU are sub-divisions according to the water resource availability and the management of water.

B1.4.1 Quantitative Status

Quantitative Status is defined by the quantity of groundwater available as base flow to watercourses and water-dependent ecosystems and as ‘resource’ available for use as drinking water and other consumptive purposes. It is assigned on a scale of Good or Poor, and on the basis of four classification elements or ‘tests’ as follows:

Saline or other intrusions - This test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions.

Surface water - This test is designed to identify groundwater bodies where groundwater abstraction is leading to a significant diminution of the Ecological Status of associated surface water bodies.

Groundwater Dependent Terrestrial Ecosystems (GWDTE) - This test is designed to identify groundwater bodies where groundwater abstraction is leading to significant damage to associated GWDTE.

Water balance - This test is designed to identify groundwater bodies where groundwater abstraction exceeds the 'available groundwater resource', defined as the rate of overall recharge to the groundwater body itself less the rate of flow required to meet the ecological needs of associated surface water bodies and GWDTE.

B1.4.2 Chemical Status

Chemical Status is defined by the concentrations of a range of key pollutants, by the quality of groundwater feeding into watercourses and water-dependent ecosystems and by the quality of groundwater available for drinking water purposes. This is assigned on a scale of Good or Poor, and on the basis of five classifications elements or 'tests', as follows:

Saline or other intrusions - This test is designed to identify groundwater bodies where the intrusion of poor quality water, such as saline water or water of different chemical composition, as a result of groundwater abstraction is leading to sustained upward trends in pollutant concentrations or significant impact on one or more groundwater abstractions.

Surface water - This test is designed to identify groundwater bodies where groundwater is leading to a significant diminution of the chemical status of associated surface water bodies.

GWDTE - This test is designed to identify groundwater bodies where groundwater is leading to significant damage to associated GWDTE.

Drinking Water Protected Areas (DrWPA) - This test is designed to identify groundwater bodies failing to meet the DrWPA objectives defined in Article 7 of the WFD or at risk of failing in the future. The aim is no deterioration in quality of waters for human consumption.

General quality assessment - This test is designed to identify groundwater bodies where widespread deterioration in quality has, or will, compromise the strategic use of groundwater. The aim is no significant impairment of human use of groundwater and no significant environmental risk from pollutants across a groundwater body.

Status is assessed primarily using data collected from the Environment Agency monitoring network; therefore the scale of assessment means that groundwater status is mainly influenced by larger scale effects such as significant abstraction or

widespread diffuse pollution. The worst case classification is, as with surface water bodies, assigned as the overall groundwater body status, in a 'one-out all-out' system. This system is summarised below in **Figure B2.4.**

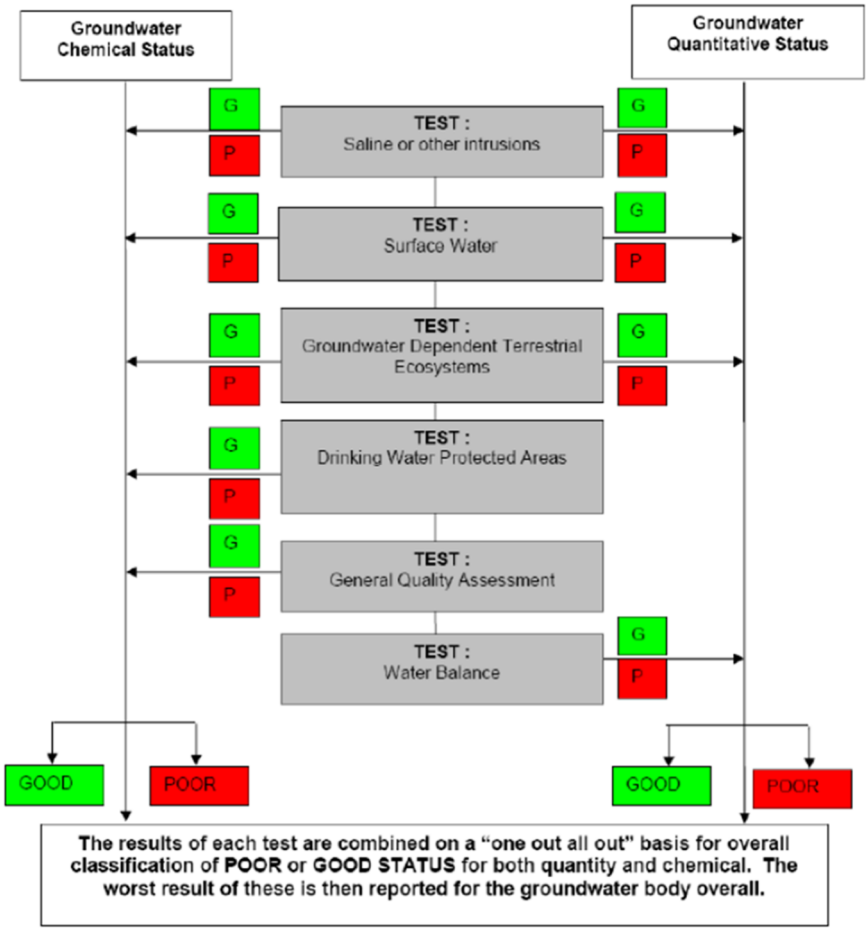

Figure B2.4: WFD classification elements for groundwater body status. [Source: Environment Agency Groundwater Quantitative Status Assessment (Classification) Method Statement]

B1.5 Assessing Deterioration

Any activity that has the potential to have an impact on ecological status of a water body (as defined by the biological, physic-chemical, and hydromorphological quality elements) needs consideration as to whether it could cause deterioration in the current Ecological Status or Ecological Potential classification. Deterioration is reported as a negative change between classes in Ecological Status or Potential (e.g. from Good to Moderate status).

Moreover, all activities that could impact on watercourses also need to be considered in terms of whether they will compromise the ability of the water body to reach Good Ecological Status or Good Ecological Potential by the date specified in the RBMP.

Appendix C

LA 113 Detailed Assessment Results

C1 HEWRAT detailed assessment

C1.1 Introduction

The assessment of potential effects from routine runoff on surface water quality has been undertaken using the Highways England Water Risk Assessment Tool (HEWRAT), as prescribed in LA113.

C1.2 Methodology

HEWRAT adopts a tiered approach as follows:

- Step 1: Runoff quality. This predicts concentrations of pollutants in untreated and undiluted highway runoff prior to any treatment and dilution in a water body.
- Step 2: In-river impacts. This predicts concentrations of pollutants after mixing within the receiving water body. At this stage, the ability of the receiving watercourse to disperse sediments is considered and, if sediment is predicted to accumulate, the potential extent of sediment coverage (i.e. the deposition index, DI) is also considered. Step 2 also incorporates two 'tiers' of assessment for sediment accumulation, based on different levels of input parameters. If one or more risks are defined as unacceptable at Tier 1, i.e. 'fail', then a more detailed Tier 2 assessment is undertaken, requiring values for further parameters relating to the physical dimensions of the receiving watercourse.
- Step 3: In-river impacts with mitigation. Steps 1 and 2 assume that the road drainage system incorporates no mitigation measures to reduce the risk. Step 3 includes mitigation in the form of Sustainable Drainage Systems (SuDS), taking into account the risk reduction associated with any existing measures or any proposed new measures.

Cumulative assessment within HEWRAT

The cumulative impacts of the scheme were calculated following the DMRB guidance. The combined effect of two outfalls into the same watercourse within the same 'reach'[10] are assessed by combining the contributing impermeable areas to the affected basins.

For solutes, cumulative effects have been considered where proposed outfalls are within 1km of each other (stream length) and discharge into the same watercourse. For sediment, cumulative impacts have been considered where proposed outfalls are less than 100m apart.

Environmental Quality Assessments within HEWRAT

A long-term impact assessment of surface water runoff from the highway has been undertaken by comparing the annual average concentrations of copper and zinc predicted in the HEWRAT results with the EQSs stated in the WFD (Standards and Classifications) Directions 2015.

[10] Reach – The distance between two outfalls into the same watercourse.

The study area for the HEWRAT assessment encompasses all the watercourses that would receive road runoff from the Scheme (Volume 2, Figure 7.1).

Input parameters

The parameters, methods of derivation and sources of information used in the assessment are listed in Table 9.

Table 9 Inputs used for the surface water quality assessment

Parameter	Information Source(s)
Two-way annual average daily traffic (AADT)	Figures provided from the traffic model. The two-way Annual Average Daily Traffic (AADT) for the A40 mainline ranges from 10,000-15,000 at the design year (2037). This falls within the 0-50,000 AADT range of the HEWRAT assessment.
Climatic conditions	Selected within HEWRAT. The scheme is within the 'warm and wet' region and with a standard average annual rainfall of 1111.7mm (Cardiff).
Q95 flow of the receiving watercourse	Catchment descriptors obtained from the FEH Web Service and Q95 subsequently derived using the FEH Lowflows tool, the standard method for estimating Q95 in the absence of monitoring data. The estimated values have been ground-truthed via site walkover. All receiving watercourses aside from the location receiving runoff from Attenuation Basin A are headwater streams with low estimated Q95 values <0.001m^3/s. With larger upstream catchment, the value generated by the Lowflows tool for the Basin A outfall was 0.002m^3/s (3dp).
Base flow index (BFI)	Obtained from the FEH Web Service for each catchment.
Drainage areas	Impermeable area (e.g. highway) and permeable area (e.g. cutting/slope drainage) to each outfall has been calculated from the design drawings of the scheme.
Water hardness	The water hardness was estimated based on Dwr Cymru Welsh Water's (DCWW's) online checking service[11] at 70 mg/l CACO3, placing it within the Medium category for HEWRAT. This hardness of the local water supply (Narberth - SA67 7DW) was assumed to be a robust proxy of the water hardness in local watercourses/runoff in the absence of water quality testing.
Physical attributes of the receiving watercourse	Watercourse dimensions and Manning's n have been estimated based on a site walkover. Watercourse long slope has been estimated based on available topographic mapping.

Table 10 lists the receiving watercourse, Q95 and drainage areas for each outfall on the new section of A417 and side roads.

The proposed discharge locations were screened against the location of protected areas (e.g. SSSIs, SACs). Outfall locations less than 1km upstream of a protected site require more stringent pollutant thresholds to be applied. With the closest downstream designated site, the Cleddau Rivers SAC, approximately 1.9km downstream of the outfall associated with Basin A, these more stringent criteria were not applied for any of the outfalls.

[11] Dwr Cymru Welsh Water: http://www.dwrcymru.com/en/In-Your-Area/Water-Quality.aspx

Results

The HEWRAT results, provided in Table 11 show that, following incorporation of the watercourse characteristics, the surface water quality of the undiluted runoff for outfalls associated with attenuation basins A, C and D pass both the EQS and acute impacts levels tested against in the HEWRAT model. Basin E failed the acute impacts test for copper only. The outfall associated with attenuation basin B failed on acute impacts for both copper and zinc and exceeded the EQS value for copper; with a value of 1.19 ug/l.

As instructed within LA 113, CG 501 Design of highway drainage systems would be used to inform the mitigation measures required. Drainage features would be designed in accordance with DMRB HA103/06 Vegetated Drainage Systems for Highway Runoff.

Due to the outputs of HEWRAT Step 2, the design of the drainage features for Basin B and E have been amended. In terms of CG 501, Table 8.6.4N3 terminology, this included incorporating a forebay within Basin B and E; qualifying them as a ‘pond’. Treatment efficiencies are given in Table 10. Following this, both passed all sections of the HEWRAT surface water assessment.

Table 10 Input values for the HEWRAT assessments. Undertaken using the approach detailed in Section 3.6-14 of LA 113.

Outfall	Chainage	Receiving Water	Receiving water-course Q95 (3dp)	Impermeable Area (ha)	Permeable Area (ha)	BFI	Down-stream structure	Protected Site down-stream	River Width (estimated)	Side Slope	Watercourse Gradient
Basin A	0+000	Narberth Brook	0.002	0.868	0.379	0.635	N	N	1	1	0.034
Basin C	0+320	Narberth Brook	≤0.001	0.3	0	0.635	N	N	1	1	
Cumulative (A and C)				1.168	0.379	0.635	N	N	1	1	0.034
Basin B	1+350	Afon Marlais	≤0.001	1.828	0.572	0.56	N	N	1	1	0.067
Basin D	0+730	Afon Marlais	≤0.001	0.272	0	0.56	N	N	1	1	0.026
Basin E	1+780	Afon Marlais	≤0.001	1.077	0.389	0.551	N	N	1	1	0.049

Table 11 Outputs from the HEWRAT assessments. Undertaken using the approach detailed in Section 3.6-14 of LA 113. P = pass, F= fail.

Outfall	Chainage	Watercourse	Step 1			Acute Impacts		Step 2			% Treatment required			Step 3				Acute Impacts	
			Copper	Zinc	Sediment	Copper	Zinc	Copper (ug/l)	Zinc (ug/l)	Sediment	Copper	Zinc	Sediment	Proposed Mitigation	Copper (ug/l)	Zinc (ug/l)	Sediment	Copper	Zinc
Basin A and Basin C (cumulative assessment)	0+000 and 0+320	Narberth Brook	P	P	P	P	P	0.51 (P)	1.84 (P)	P			N/A						
Basin B	1+350	Afon Marlais	F	P	P	F	F	1.19 (F) -	4.29 (P)	P	20		N/A	Detention pond: Copper 40%, Zin 30%, Sediment 60%	0.71	-	-	P	P
Basin D	0+730	Afon Marlais	P	P	P	P	P	0.26 (P)	0.98 (P)	P			N/A						
Basin E	1+350	Afon Marlai	P	P	P	F	P	0.81 (P)	2.95 (P)	P			N/A	Vegetated ditch: Copper 15%, Zinc 15%, Sediment 25%	- (0.69)	- (2.51)	P	P	P

C2 Groundwater Dependant Terrestrial Ecosystem Assessment

In accordance with LA 113 the scheme has been reviewed in the context of potential impact to groundwater levels and flow, through the development of a conceptual site model and subsequent identification of all potential features which are susceptible to groundwater level and flow impacts. This includes an assessment of potential impacts upon Groundwater Dependant Terrestrial Ecosystems.

The results of this assessment are presented in Volume 3, Appendix 7.4.

C3 Groundwater Quality and Run off Assessment

LA113 provides a methodology within Appendix C to assess the potential impact on the quality of groundwater resources from routine runoff discharges to the ground.

This risk assessment procedure is based on the study of the source-pathway-receptor (S-P-R) protocol. The principles of this approach have been applied to the disposal of road drainage whereby the:

- Source term comprises the road drainage water with any pollutants contained therein, as it enters any unlined ditch, watercourse or soakaway discharge system, that has the potential to transmit water through the ground to groundwater;
- Pathway term represents the processes, which may modify the pollutants during transmission through the discharge system and soil and subsoil until the actual 'point of entry' to groundwater (this includes the unsaturated zone);
- Receptor, which is the groundwater.

For there to be a risk of impact to groundwater, all elements of the S-P-R model have to be present to create a pollutant linkage.

The drainage solution for the proposed A40 scheme includes five attenuation basins (Labelled A to E, shown in Volume 2, Figure 7.3) that discharge to the surface water courses. For the purpose of the assessment, it has been assumed that the attenuation basins will act as a soakaway and the data incorporated into the assessment is based on the basin invert levels. It is acknowledged this is unlikely due to high groundwater levels; however, this has been assumed following worst-case scenario.

The method uses the tables below to determine the risk score, by incorporating the key factors affecting level of risk posed by the source of pollutants, the persistence and movement of pollutants within the pathway to groundwater and linkages between them. In this way the matrix provides a means of ranking specific road drainage discharge sites in terms of their potential risks to groundwater.

Table 12 Overall Risk Score for Existing Site Conditions – Basin A

Component Number		Weighting Factor	Property or Parameter	Site Data	Risk Score	Component Score
1	SOURCE	10	Traffic flow	<50,000	1	10
2		10	Rainfall depth (annual averages)	>=1060mm	3	30
3		10	Drainage area ratio	<=50 (19)	1	10
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30
5		20	Unsaturated Zone	Depth to water table <15 m to >5 m	2	40
6		20	Flow Type (incorporates flow type and effective grain size)	Dominantly intergranular	1	20
7		5	Unsaturated zone clay content	<=1%	3	15
8		5	Organic Carbon	<=1% SOM	3	15
9		5	Unsaturated zone pH	pH <8 to >5	2	10
					Overall Risk Score	**180**
						Medium

Table 13 Overall Risk Score for Existing Site Conditions – Basin B, C, D and E

Component Number		Weighting Factor	Property or Parameter	Site Data	Risk Score	Component Score	
						B, D and E	C
1	SOURCE	10	Traffic flow	<50,000	1	10	
2		10	Rainfall depth (annual averages)	>=1060mm	3	30	
3		10	Drainage area ratio	<=50 B = 26 D = 6 E = 48	1	10	
				>50 to <150 C = 136	2		20
4	PATHWAY	15	Infiltration method	"Region", shallow infiltration systems (e.g. infiltration basin)	2	30	
5		20	Unsaturated Zone	Depth to water table <=5 m	2	40	
6		20	Flow Type (incorporates flow type and effective grain size)	Flow dominated by fractures/ fissures	1	20	
7		5	Unsaturated zone clay content	>=15%	3	15	
8		5	Organic Carbon	<=1% SOM	3	15	
9		5	Unsaturated zone pH	pH <8 to >5	2	10	
					Overall Risk Score	**230**	**240**
						Medium	

C3.1.1 Source (applied to all scenarios)

Traffic Flow (component number 1)

Figures provided from the traffic model. The two-way Annual Average Daily Traffic (AADT) for the A40 mainline ranges from 10,000-15,000 at the design year (2037). This falls within the 0-50,000, low risk AADT range.

Rainfall Depth (component number 2)

According to the Flood Estimation Handbook (FEH), the average annual rainfall for the Scheme is 1300mm, Falling into the high-risk category >=1060mm.

Drainage Area Ratio (component number 3)

According to the drainage design (Volume 2, Figure 7.3), the drainage ratio area for all basin aside from C fall into the low risk <=50 category. Basin C falls into the medium risk >50 to <150 category.

C3.1.2 Pathway

Infiltration method (component number 4)

As stated above, it has been assumed that the attenuation basins will act as soakaways and the data incorporated into the assessment is based on the basin invert levels.

Unsaturated Zone (component number 5)

The Ground Investigation study carried out for the scheme in summer 2019 informed groundwater levels. Levels were typically recorded close to basin invert levels for all basins aside from Attenuation Basin A; where groundwater fell in the medium risk category of 5 to 15m below the basin invert level.

Flow Type (component number 6)

The scheme is underlain by two types of bedrock. Beneath Basin A is Haverford Beds weathered bedrock; dominantly intergranular and low risk score and beneath all other Basins is Slade and Redhill bedrock, which is heavily manufactured mudstone and falls into the high-risk category of flows dominated by fractures/fissures.

Unsaturated Clay Content (component number 7)

Based on literary values, pending results returning from the lab, the clay content for the respective unsaturated zones is considered to be <1% for Basin A and >15% for all other Basins.

Organic Carbon (component number 8)

Based on chemical results, the organic carbon content is shown to be <1% low risk levels. Due to no chemical testing for Basin E, an estimate was provided based on nearby averages and chemical testing values.

Unsaturated zone soil content

Pending the return of Geotech results, the chemical results show a pH of <8 to >5; medium risk score for each basin.

Overall Risk Score

The risk scores of between 180 and 240 are within the 150 – 250 DMRB suggested action class range, which indicates there is a **medium risk of impact.**

For the medium risk impact mitigation measures should be considered to protect groundwater, the DMRB guidance suggests the need for and nature of the mitigation measures should be informed by additional risk assessment.

Following step 3 of the HEWRAT process, the pollutant concentrations within the runoff from each basin aside from E and B is below EQS values without incorporating mitigation.

It should be noted that, as the AADT value is in the lower range of 0-50,000; both the HEWRAT and the Method C risk scores are greater than the real concentrations.

Basin E requires <5% mitigation for acute copper impacts only and Basin B requires mitigations for copper and zinc. The incorporation of a forebay into attenuation basin E will reduce the acute impacts of copper passing concentration. With lined drainage ditches and a forebay incorporated into attenuation basin B, there is no infiltration to ground water prior to pollutant attenuation within the attenuation pond. Therefore, for both ponds, the copper and zinc values are reduced to below EQSs prior to release into surface or ground water.

For all ponds, the source of contamination is below the EQS value, removing the ‘source’ of the source – pathway – receptor process. Therefore, no further assessment; which would have taken the form of MBAT and RD20 is necessary.

C4 Spillage Risk Assessment

C4.1 Background

Assessment of the risk of accidental spillages has been carried out using Appendix D as prescribed in DMRB LA113 (Highways Agency et al., 2019) to ensure provision of appropriate drainage design measures where the risk of a serious pollution incident is more frequent than the 1% annual exceedance probability (AEP) (or more frequent than 1 in 100 year return period).

The results of the assessment are reported as 'pass' or 'fail'. The risk of an acute pollution incident due to accidental spillage or vehicle fire is considered proportionate to the risk of a heavy goods vehicle (HGV) road traffic collision. Thus, the percentage of HGV's on a given road is the main parameter used in assessment of the risk of serious pollution accidents.

Other parameters considered include the type and length of road, two-way annual average daily traffic (AADT) flow and emergency services response time depending on whether a site is in an urban, rural or remote setting. If the accidental spillage is less than or equal to 1% AEP (or 0.5% AEP for sensitive watercourses), the risk is considered acceptable.

Vehicle numbers from the design year 2037 AADT flows have been used to account for future growth.

C4.2 Results

Detailed results of the Appendix D assessment are given in Table 14 and the summary values are in Table 15 below. The accidental spillage risk assessment results show that, without consideration of the drainage scheme, there would be no discharge with a serious spillage risk more frequent than the 1% and 0.5% AEP (1 in 100 year and 1 in 200 year return period) thresholds.

Table 14 Results of the Spillage assessment. Undertaken using the approach detailed in Appendix D of LA 113 based on traffic flow in design year 2051.

Location	Road Reference	Start chainage (m)	End chainage (m)	Length (m)	Receiving reach	Junction Type	Location (emergency service	2-way AADT	%HGV	Spillage Factor	Risk of accidental spillage	Risk of Pollution Incident	Risk
Basin A	A40	0+000	0+610	610	Unnamed tributary of Narberth Brook 3	Cross Road	< 1 hour	13,040	5.1	0.88	0.00013	0.00008	No
Basin B	A40	0+610	1+765	155	Unnamed Tributary of Marlais 3	No Junction	< 1 hour	11,390	5.7	0.29	0.00004	0.00003	No
Basin C	Side Road	Offline		300	Unnamed tributary of Narberth Brook 1	Side Road	< 1 hour	2,925	2	0.93	0.00001	0.0	No
Basin D	Side Road (existing A40)	Offline		240	Unnamed Tributary of Marlais 4	Side Road	< 1 hour	2,030	1	0.93	0.0	0.0	No
Basin E	Penblewin Roundabout	Offline		300	Unnamed Tributary of Marlais 1	Roundabout	< 1 hour	6,829	4	3.09	0.00009	0.00006	No

Table 15 Appendix D assessment summary values

Total annual probability	Acceptable risk (normally 1%, or 1-in-100 year)	Do individual outfall risks need to be identified?	Highest individual risk	Can the highest individual risk be reduced?
0.00017	1%	No	0.00008	No

File Note

Project	**A40 Penblewin Roundabout to Redstone Cross Improvements**
Subject	Flood Risk Note
File Reference	A40PRC-ARP-HDG-SWI-FN-D-0001
Prepared by	Aled Roberts
Status	**S3 | SUITABLE FOR REVIEW & COMMENT**
Revision | Date	P01 | 08/10/19

1 Introduction

In December 2004, the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study followed a number of previous reports that all concluded that the A40 needed improvement.

Arup (supported by RML) were instructed by Welsh Government in January 2019, to progress all works necessary to facilitate design development, environmental impact assessment and publication of draft Orders for a Wide Single 2+1 (WS2+1) solution between Penblewin Roundabout and Redstone Cross. A WS2+1 road consists of two lanes of travel in one direction and a single lane in the opposite direction. This provides overtaking opportunities in the two-lane direction, while overtaking in the single-lane direction is prohibited.

The Penblewin to Redstone Cross Improvements Scheme (hereby referred to as 'the Scheme') should not be confused with the Llanddewi Velfrey to Penblewin Improvements.

2 Technical Note Purpose

This note aims to identify the risks imposed by the Scheme in relation to flooding. The following types of flooding were considered:

- Fluvial flooding
- Surface water and highway flooding
- Groundwater flooding
- Coastal flooding.

The risk posed, if any, from each type are quantified using the relevant statutory guidance and any subsequent requirements for the Scheme identified.

3 Flood Risk

3.1 Fluvial flooding

Technical Advice Note 15 (TAN 15) – Development and Flood Risk (2004) provides technical guidance which supplements the policy set out in Planning Policy Wales, November 2016 (PPW) in relation to development and flooding. This provides a framework within which risks arising from fluvial, tidal flooding, and runoff can be assessed.

The Natural Resources Wales (NRW) and TAN 15 Development Advice Maps (DAMS) identify areas of extreme flood risk categorised into three zones (A, B and C with subdivision into C1 and C2). An extract of the DAMS Flood Risk Map in the vicinity of the Scheme is provided in Figure 1. The entirety of the Scheme is located within Zone A and is considered to be at little or no risk of flooding. Therefore, in accordance with TAN 15, no further consideration of flood risk is required.

The NRW flood risk map shown in Figure 2 shows the Scheme is not located in an area which is at risk of fluvial flooding.

In accordance with Section 9 of TAN 15, no constraints relating to flooding are applicable, other than to avoid increasing risk of flooding elsewhere. In order to achieve this, the following principles will be followed:

- If possible, the highway runoff will be infiltrated into the ground. This could be achieved by using attenuation/ infiltration basins
- If infiltration is not possible, surface water runoff will be restricted to the 1-year return period Greenfield Runoff Rate (GRR). This will be determined from a hydrological assessment and is to be confirmed with Pembrokeshire County Council (PCC)
- Attenuation will be provided in ponds/infiltration basins, with a maximum storage depth of 2.0m with 0.5m freeboard. The ponds will be sufficient in size to accommodate the 1 in 100 year event with an allowance for climate change
- Where a new drainage system is to be provided, the restricted flow will include the GRR from the new highway. This will be the basis for calculating the required attenuation volumes, subject to confirmation from PCC
- Several watercourses/streams cross the route of the proposed Scheme. The flows in these watercourses will be maintained within their catchment through the use of cross-drainage culverts where possible
- The proposed cross-drainage culverts will be designed to convey the 100-year event flows beneath the proposed highway with an allowance for climate change. A freeboard of 300mm or a quarter of the diameter (whichever is greater) will be designed. The culverts will be designed in accordance with the requirements of the Design Manual for Roads and Bridges (DMRB), CIRIA Report C689, PCC, and may require a 150mm embedment for environmental reasons
- Where the catchment area draining to the cross-drainage culvert is not readily defined, the minimum culvert diameter will be 1200mm in accordance with the DMRB.

3.2 Surface water and highway flooding

The NRW surface water flood risk map (extract shown in Figure 2) identifies areas which are likely to be at risk of surface water flooding. The Scheme crosses some areas which have been identified as at risk of surface water flooding. These areas correspond to low spots in the existing topography where existing watercourses are present. The potential risk will be mitigated by the use of culverts as described in Section 3.1.

In addition to the principles outlined in Section 3.1, the following principles will be followed to mitigate the impacts of surface water flooding:

- The highway drainage will be designed in accordance with the requirements of the DMRB, in particular HD33/16 which considers surface water/ highway flooding
- A positive drainage system will be provided for the Scheme which will ensure that there is no surface water flooding for a 1 in 5 year return period event
- No surcharge will be present in the drainage network for a 1 in 1 year event
- The peak flows will be increased by 30% to account for the effects of climate change as requested by PCC (DMRB requires 20%).

3.3 Groundwater flooding

The topography of the site combined with the ground conditions encountered within the ongoing intrusive ground investigation does not suggest groundwater flooding will be of concern. Also, no evidence of groundwater flooding was seen during site visits.

In circumstances where the proposals will impact the groundwater levels, the principles outlined in Sections 3.1 and 3.2 and the following will be applied:

- In cuttings, the surface runoff will be drained to combined surface water/ ground water filter drains in the verge
- Lined cut-off ditches at the top of cuttings and unlined cut-off ditches at bottom of embankments will intercept natural runoff. If the natural topography falls away from the road alignment, cut-off ditches will not generally be provided other than to mitigate local flooding risk
- Any existing land drains encountered will be intercepted and diverted to cut-off ditches
- Attenuation ponds/infiltration basins will be designed to ensure that groundwater will not impede their performance.

3.4 Coastal flooding

Coastal flooding is not considered a risk due to the elevation and distance of the Scheme above/from the coast.

4 Conclusions

As the Scheme is located within Zone A, a Flood Consequences Assessment (FCA) is not required.

In accordance with TAN 15, no constraints relating to flooding are applicable, other than to avoid increasing risk of flooding elsewhere. All types of flooding will be suitably managed through the principles outlined in Section 3.

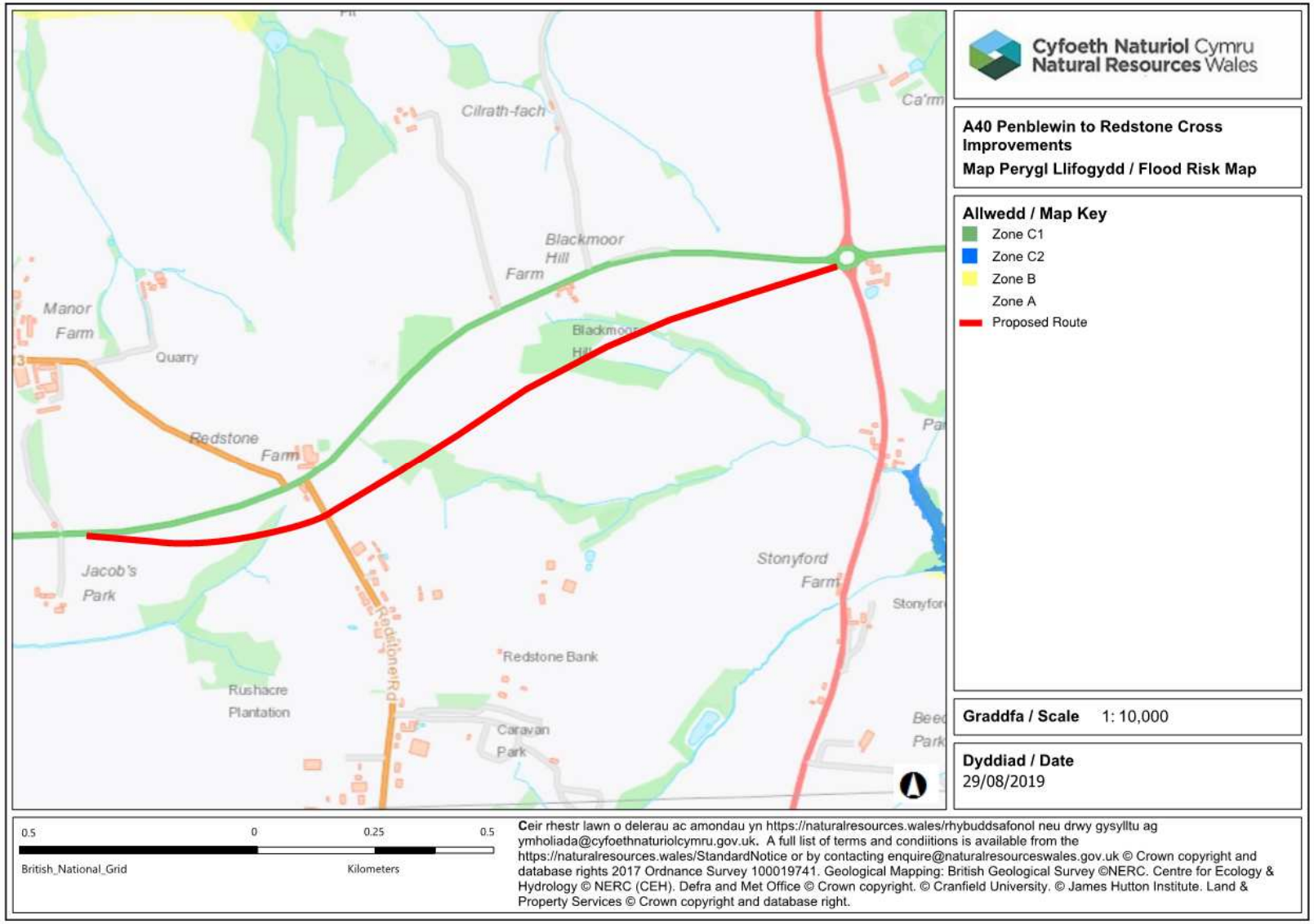

Figure 1 – NRW/ TAN 15 Development Advice Maps

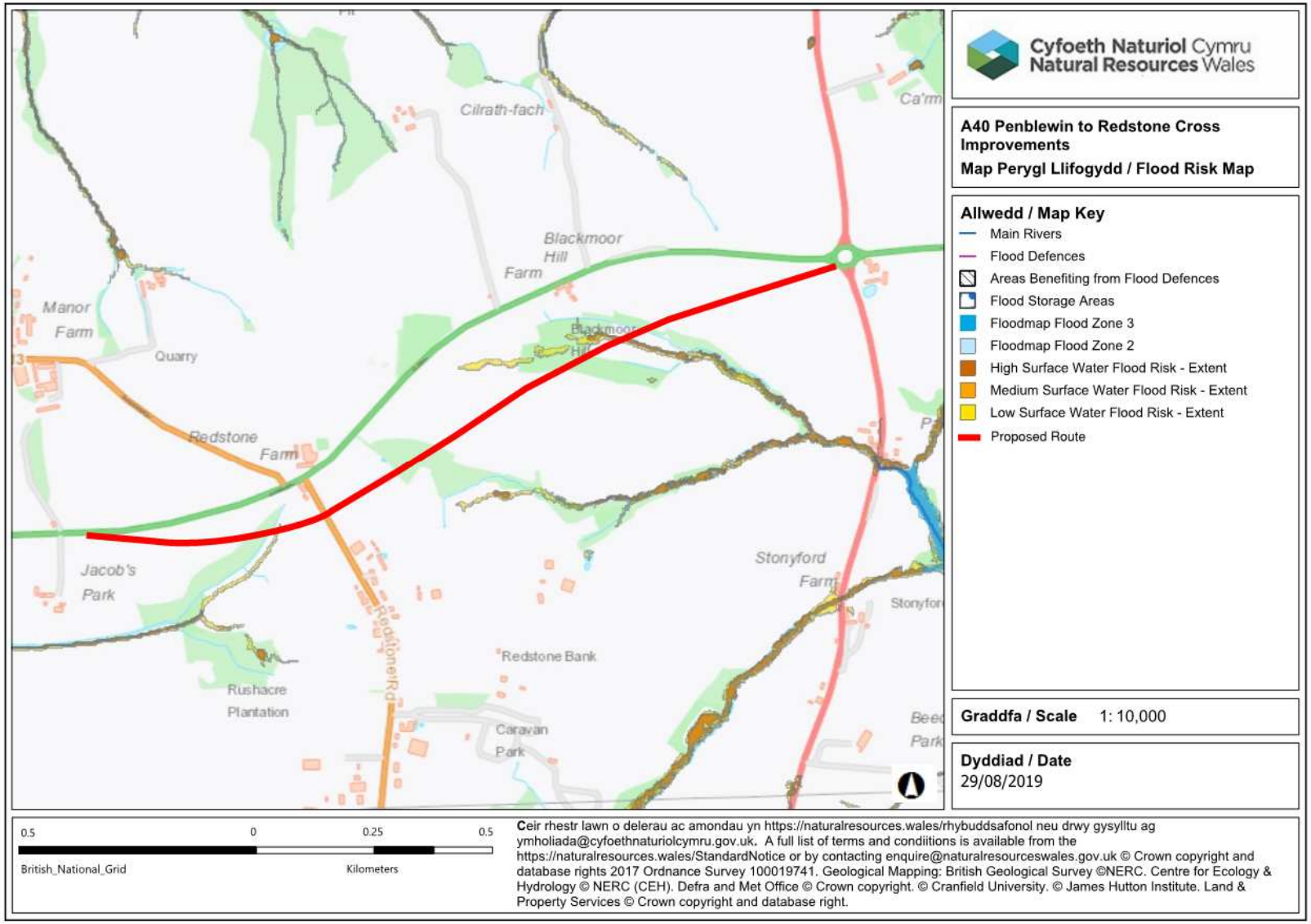

Figure 2 – NRW Flood and Surface Water

Welsh Government

A40 Penblewin to Redstone Cross Improvements

Drainage Strategy Report

A40PRC-ARP-HDG-SWI-RP-D-0001

P05 | S3

09/06/20

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Figures

Figure 1 – NRW/TAN 15 Development Advice Map Extract.
Figure 2 – NRW Flood and Surface Water Risk Map

Appendices

Appendix A – Stakeholder Correspondence
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Appendix C – Drainage Drawings
Appendix D – P2RC Hydrological Assessment

1 The Project

1.1 Context

1.1.1 In December 2004, the Welsh Government announced the outcome of the A40 West of St Clears study into the consideration of both single carriageway and dual carriageway improvements to the A40 between St Clears and Haverfordwest. This study came about as a result of a number of previous reports that all concluded that the A40 needed improvement.

1.1.2 In February 2017, the Welsh Government appointed Carillion, with Arup and RML (the 'Carillion Team') as their technical and environmental advisors, to develop the design of the proposed A40 Llanddewi Velfrey to Penblewin Improvements up to publication of draft Orders.

1.1.3 Carillion entered liquidation in January 2018. The Welsh Government subsequently appointed Arup, supported by RML, to continue the development of the design up to publication of draft Orders and to support the Welsh Government through the Statutory process.

1.1.4 Further to this, Arup, supported by RML were instructed by Welsh Government in January 2019, to progress all works necessary to facilitate design development, environmental impact assessment and publication of draft Orders for a WS2+1 solution between Penblewin Roundabout and Redstone Cross.

1.2 Project history

1.2.1 In December 2004, the Minister announced the publication of his Addendum to the 2002 Trunk Road Forward Programme (TRFP) and this included two major single carriageway improvement schemes for the A40 west of St Clears. The improvements would use the 2+1 configuration allowing overtaking on the two-lane direction, with overtaking prohibited in the one-lane direction and would be delivered in the following phases:

a) A40 Penblewin - Slebech Park

b) A40 Llanddewi Velfrey - Penblewin.

1.2.2 The first of these projects, Penblewin - Slebech Park, was completed in March 2011.

1.2.3 In July 2013, Edwina Hart AM CStJ MBE, Minister for Economy, Science and Transport, published a written statement outlining her priorities for Transport. The statement included the following:

> *"Improving the A40 has been identified as a priority by the Haven Waterway Enterprise Zone Board and I intend to undertake further development of previously proposed improvements."*

1.2.4 On 12 November 2014, in providing an update on the closure of the Murco Refinery in Milford Haven, the Minister made an oral Statement in Plenary:

> *"In terms of transport links, I have instructed my officials to accelerate to the fullest extent possible the programme for delivering improvements at Llanddewi Velfrey."*

1.2.5 In June 2015, in a written statement on the A40 Improvement Study the Minister noted *"It is my intention to progress delivery of the A40 Llanddewi Velfrey to Penblewin scheme as soon as possible…"*

1.3 The problems

1.3.1 The following problems have been identified in collaboration with the A40 Llanddewi Velfrey to Penblewin Improvements Scheme and early public engagement for the A40 Penblewin to Redstone Cross Improvements Scheme:

a) The A40 mainline and Redstone Cross Junction is substandard
b) Limited overtaking opportunities lead to poor journey time reliability and driver frustration.
c) Occasional convoys of heavy goods vehicles from the ferry ports and slow moving agricultural vehicles contribute to periods of platooning and journey time unreliability, which is exacerbated with limited overtaking opportunities.
d) Seasonal spikes in traffic volumes along the A40 especially during the summer months leads to slow moving traffic causing journey time unreliability, which is exacerbated with limited overtaking opportunities.
e) There are many side road junctions and direct accesses to properties and agricultural fields off the A40, which contributes to operational problems along the road.

f) A mix of traffic types using the road, contributing to journey time unreliability and driver frustration, risky manoeuvres and collision incidents.

g) A lack of strategic public transport connectivity in Pembrokeshire generally means there is a dependence on the private car for inter-urban connections.

1.4 Scheme objectives

1.4.1 A number of transport planning objectives have been developed iteratively during previous development work and engagement on the A40 project, aiming to address one or more of the identified problems. During the early stages of Key Stage 3 the problems and objectives were refreshed during a focused workshop event with key stakeholders to take into account the WelTAG 2017 guidance and Wellbeing of Future Generations (Wales) Act wellbeing goals. The scheme objectives are:

O1 To enhance network resilience and improve accessibility along the east-west transport corridor to key employment, community and tourism destinations.

O2 To improve prosperity and provide better access to the county town of Haverfordwest, the Haven Enterprise Zone and the West Wales ports at Fishguard, Milford Haven and Pembroke Dock.

O3 To reduce community severance and provide health and amenity benefits.

O4 To improve the Redstone Cross Junction safety (and perceived safety) and reduce the number and severity of A40 mainline collisions.

O5 To promote active travel by cycling, horse riding and walking to provide opportunities for healthy lifestyles.

O6 To deliver a scheme that promotes social inclusion and integrates with the local transport network to better connect local communities to key transport hubs.

O7 Deliver a project that is sustainable in a globally responsible Wales, taking steps to reduce or offset waste and carbon.

O8 Give due consideration to the impact of transport on the environment and provide enhancement when practicable.

1.5 Purpose of this report

1.5.1 The report sets out the highway drainage design principles and parameters for discussion and agreement with Welsh Government, Natural Resources Wales (NRW), Pembrokeshire County Council (PCC) and other relevant statutory bodies.

1.5.2 The report addresses the drainage strategy relating to the permanent works for the A40 Penblewin to Redstone Cross Improvements (the "Scheme") and does not deal with the temporary works and construction drainage requirements.

1.6 Report Structure

1.6.1 This report has the following sections:

Section 2 - Flooding

Section 3 - Existing Highway Drainage

Section 4 - Proposed Drainage

Section 5 - Attenuation

Section 6 - Cross Drainage

Section 7 - Water Quality

Section 8 - Elements of High Risk or Complexity.

2 Flooding

2.1.1 Technical Advice Note 15 (TAN 15) – Development and Flood Risk (2004) provides technical guidance which supplements the policy set out in Planning Policy Wales, December 2018 (PPW) in relation to development and flooding. This provides a framework within which risks arising from fluvial, tidal flooding, and runoff can be assessed.

2.1.2 TAN 15 Development Advice Maps (DAMS) indicate the areas of extreme flood risk in three zones (A, B and C with subdivision into C1 and C2). Zone A, indicated as white areas on the DAMS is considered to be at little or no risk of flooding

2.1.3 The DAMS show that the entirety of the proposed Scheme is located within Zone A, see Figure 1. Section 9 of TAN 15 confirms that within Zone A, no constraints relating to river or coastal flooding, other than to avoid increasing risk of flooding elsewhere.

2.1.4 The NRW flood and surface water risk map can be seen in Figure 2. This shows that the site is at very low risk (less than 1 in 1000 year) of fluvial flooding. Figure 2 also shows that a section of the proposed route near to Blackmoor Hill has medium to low risk of surface water flooding. The extents of the flooding is consistent with the natural terrain and follows the existing watercourse. The risk of the surface water flooding would be dealt with through appropriate placing of culverts and cut-off ditches to allow the existing surface water catchments to be maintained.

2.1.5 NRW confirmed via email (Appendix A) on 04/11/2019 that a Flood Consequences Assessment (FCA) is not required due to the proposed route being located within Zone A.

3 Existing Highway Drainage

3.1.1 The Scheme largely consists of offline improvements but has small sections of online works. The new works on the line of the existing highway would replace the existing drainage.

3.1.2 Considering the age of the existing highway and through site visit observations and analysis of highway record drawings, it has been assumed that no pollution control or attenuation measures currently exist.

3.1.3 The following information has been assumed based on site visit observations, imagery and highway record drawings. Where required, information would need to be confirmed via appropriate surveys. Drawings showing the highway drainage details from 180m to the west of the Redstone Cross junction to the Penblewin Roundabout have been received from South Wales Trunk Road Agency (SWTRA) (email 27/11/2019) and the proposed design has been adapted and developed on this basis. Records of the highway drainage are included in Appendix B.

3.1.4 It is noted that the drawings received from SWTRA do not cover the whole extent of the scheme. Additionally, their drawing status are 'For Information' and 'Tender Issue. Therefore, where needed, the information shown on the drawings will need to be confirmed at detailed design.

3.2 Western Tie-in (Jacob's Park) to Redstone Cross

3.2.1 The existing A40 section between the proposed western tie-in near Jacob's Park and Redstone Cross is drained via conventional kerbs and gullies. Some sections within the cutting (near the Redstone Cross junction) have filter drains located within the verge.

3.2.2 SWTRA drawings show that the Redstone cross junction and a 160m section of the existing A40 are drained by gullies and discharge into the existing local watercourse to the south west of the junction. The drawings also indicate a drainage connection from the B4313 into the Redstone Cross junction drainage. Based on the ground level drainage assets, it is estimated that 400m of the B4313 drains into this outfall.

3.2.3 The level of the highway to the west of the junction falls to the west. The SWTRA drawings show that the existing drainage continues to the west. However, the drawing extents do not show the outfall of this drainage. The low point of this section is at the tie-in location near Jacob's Park and it is assumed the existing drainage continues westwards to a low point and subsequently discharges to a watercourse.

3.3 Redstone Cross to Penblewin Roundabout

3.3.1 The section of road between Redstone Cross and Penblewin Roundabout (to the east) is drained via conventional kerbs and gullies with some sections of filter drains. The site topography shows that the eastbound layby is at the high point of this section of highway.

3.3.2 The SWTRA drawings show that the highway drainage runs into three separate highway catchments. The western catchment from Redstone cross to the eastbound layby. The central catchment includes the eastbound lay-by and its surrounding carriageway. The eastern catchment includes the highway from the layby to the existing Penblewin roundabout.

3.3.3 The highway drainage catchment which extends between Redstone Cross and eastbound layby is shown to outfall into a field to the west of Blackmoor Farm. The extents and nature of the outfall is not shown on the SWTRA drawings; however it is expected that the outfall connects to a ditch observed in the field during the site visit.

3.3.4 The existing eastbound lay-by is drained by gullies and outfalls to the north into a field that is shown to have a pond on the OS maps.

3.3.5 There is limited information provided on the SWTRA drawings to the east of the lay-by. The vertical alignment of road falls towards the Penblewin roundabout, therefore it is assumed that the drainage follows eastwards and connects to the existing roundabout. However, there may be an outfall into the southern ditch located in the most easterly field adjacent to the existing roundabout and Penblewin farm.

4 Proposed Drainage

4.1 Review of options

4.1.1 The Design Manual for Roads and Bridges' (DMRB) '*CG 501 Design of highway drainage systems*' standard requires that different options for discharge of highway drainage are examined in the following order of preference for the destination for road runoff:

a) Ground
b) Surface watercourse
c) Surface water sewer.

4.1.2 Ground Investigation (GI) was undertaken in Autumn 2019. The scope involved undertaking investigations along the main highway route and infiltration testing at the proposed locations of attenuation basins A and B, as identified on the drainage drawings included in Appendix B. Investigations were not undertaken at other basin location as their location were not defined at the time of the GI site works.

4.1.1 Trial pit undertaken at the proposed location of basin A encountered a minimal deposit of clay-based topsoil (0.3m) overlying gravels of weathered mudstone bedrock. Groundwater was not encountered during the progression of this trial pit. Soakaway tests carried out in within the completed trail pit recorded infiltration to the ground (a rate in the order of 3.07x10-5m/s – 1.57x10m-5m/s). Given these infiltration characteristics, it is possible that an attenuation basin allowing for infiltration to ground could be a feasible solution at this location and should be explored at detailed design. However, there is uncertainty regarding the groundwater level, due to the limited monitoring at this location, which may limit the feasibility of such drainage solutions.

4.1.2 Exploratory holes in the proposed location of basin B encountered clay, clayey gravels and gravelly clays to depths of 1.2 – 3.5m. Soakaway testing carried out at this location recorded negligible infiltration over the duration of the test; as expected for the underlying, predominantly cohesive, glacial till. Post fieldwork groundwater monitoring undertaken in nearby boreholes indicated a very shallow groundwater level. Due to the negligible infiltration characteristics of the ground and the anticipated shallow groundwater

level, it is unlikely that an attenuation basin allowing for infiltration to ground would be a feasible drainage solution; a drainage strategy of discharge to watercourse was considered the likely feasible option for all basins and is discussed further in the following sections.

4.2 Drainage strategy

4.2.1 The hierarchy of discharge destination has been followed, as outlined in DMRB CG 501. The potential for infiltration has been considered prior to other options. Based on initial ground investigation results, infiltration is unlikely to be a feasible disposal option.

4.2.2 Therefore, the proposed drainage strategy is to discharge surface water to watercourses. In accordance with the requirements of the Lead Local Flood Authority (PCC), the surface water would need to be attenuated and discharged to the watercourses at Greenfield Runoff Rate (GRR).

4.2.3 GRR is the rate of run-off that would occur from the site in its undeveloped and therefore undisturbed state. The method and calculation for determining GRR is provided in the Penblewin to Redstone Cross Hydrological Assessment File Note. This GRR was confirmed through a hydrological assessment using the FEH Statistical Method/ Revitalised Flood Hydrograph (ReFH 2.2). The methodology to estimate the flow rate was discussed in a meeting with PCC and confirmatory email on 08/08/2019 (Appendix A). The GRR value for QMED was estimated to be 5.2l/s/ha and the Hydrological Assessment is included in the Appendix C.

4.2.4 Ground investigations have been undertaken for both basin A and B. Initial ground investigation on site indicated that infiltration may be possible for basin A but not at B. Further investigation will be required to assess the other basins and to evaluate basin A. If infiltration is not an option for any of the basins the proposed surface water discharge is to be attenuated to a Greenfield Runoff Rate (GRR) of 5.2 l/s/ha for all events up to a 100 year return period including a 30% allowance for climate change prior to discharge into adjacent watercourses.

4.2.5 The proposed strategy for attenuating the surface water is through the use of attenuation basins. Attenuation/infiltration basins would have a maximum storage depth of 2.0m with 0.5m freeboard to the top of the

basin for a 100 year return period including a 30% allowance for climate change. Side slopes would be 1 in 3, with one side slope of 1 in 5. Total water depth within basin would be 2m where possible, but this may increase in certain instances due to the terrain and land constraints. The design would be in accordance with DMRB HA103/06 Vegetated Drainage Systems for Highway Runoff.

4.2.6 To restrict flows from the attenuation basins to the watercourses, flow control devices would need to be included within the proposed basin outlets. There may be a requirement for penstock valves to allow for proper maintenance and management of a pollutant spillage.

4.2.7 The drainage system will be designed in accordance with the requirements of DMRB. In general, the following principles would be followed:

a) Highway drainage will be designed to cater for a 1 in 1 year return period with a 30% allowance for climate change without surcharging.

b) The design will ensure that there is no surface flooding for a 1 in 5 year return period with a 30% allowance for climate change .

c) The design will ensure the attenuation/infiltration basins can accommodate the 1 in 100 year event with a 30% allowance for climate change, as required and agreed with PCC on 7/8/19.

d) The overland flow routes will be assessed for events up to 1 in 100 year with 30% allowance for climate change to and ensure that there is no flooding of third party land up to this event.

e) The rainfall intensity which informs the pipe and pond sizing will be increased by 30% to account for the effects of climate change as required by PCC.

4.2.8 The proposed strategy for collecting surface water runoff from the edges of the road is as follows:

a) Cuttings - combined surface water/ ground water filter drains in the verge in accordance with the Manual of Contract Documents for Highway Works' (MCHW) Highway Construction Detail (HCD) B1 Type 1A.

b) Embankments - kerb and gully outlets to carrier pipes in accordance with HCD B9 Type 21A.

c) Lined cut-off ditches at the top of cuttings and unlined cut-off ditches at bottom of embankments will intercept natural runoff. If the natural topography falls away from the road alignment, cut-off ditches would not generally be provided other than to mitigate local flooding risk.

d) Any existing land drains encountered would be intercepted and diverted to the cut-off ditches.

4.2.9 To allow maintenance of the basins, vehicular access tracks will be provided to the basins. These will be 3m wide and constructed from unbound material. Access to the culverts would also need to be considered. It is proposed that access to both upstream and downstream of the culverts can be obtained within the highway easement at the toe of the embankment.

4.2.10 More details of the proposed drainage is summarised below. The chainages can be found on the drainage drawings.

4.3 Proposed Catchments

Catchment A (Ch 0+000 to Ch 0+610)

4.3.1 This section of the Scheme would drain to a low point at Ch 0+020. From here, the proposed drainage infrastructure would discharge surface water to Attenuation/Infiltration Basin A. This would discharge surface water into the adjacent watercourse at a controlled rate if required.

4.3.2 The proposed highway would be drained via conventional kerbs and gullies whilst filter drains in the verge would take the flows from the cuttings located both at the Jacob's Park end and the Redstone Cross end.

4.3.3 A proposed 1.2m diameter culvert would pass under the highway at Ch 0+000, conveying the flow from the northern cut-off ditch and transfer it to the southern existing watercourse using another cut-off ditch south of the proposed highway. It would require a separate ecological crossing beneath the highway.

4.3.4 A proposed culvert at Ch 0+440 would convey the flow from the northern cut-off ditch that serves the surrounding land under the highway and towards another culvert. This would then transfer the flow beneath the connector road and to the existing watercourse to the south-west. The culvert has been enlarged to accommodate ecological requirements.

4.3.5 The existing A40 carriageway to the west of Redstone Cross is to be

broken up and returned to a field. SWTRA drawings indicate that the highway drainage to the west of Redstone cross flows westwards and the existing drainage infrastructure, up to the A40 tie-in location, can be removed.

Catchment B (Ch 0+610 to Ch 1+779)

4.3.6 This section of the Scheme would drain to a low point at Ch 1+278. From here, the proposed drainage infrastructure would discharge surface water to Attenuation Basin B. This would discharge surface water into the adjacent watercourse at GRR.

4.3.7 The proposed highway would be drained via conventional kerbs and gullies whilst filter drains would take the flows from the cuttings located both in the Redstone Cross area and near to Penblewin Roundabout. Both would be conveyed in a combined system to Attenuation Basin B. The Basin would be located within a cutting where the groundwater is expected to be shallow. There may be a risk of groundwater infiltration into the basin. Therefore, if this is the case the basin would need to be lined. There also may be a need for a filter drain to be installed around the pond to reduce the local ground water level. Based on the HAWRAT assessment this basin would need to retain a permanent water level in order to achieve water quality criteria.

4.3.8 A proposed 1.2m diameter culvert would pass under the highway at Ch 0+860, receiving flows from the northern cut-off ditches and convey them to the existing watercourse to the south. It would also act as an ecological crossing beneath the highway and on this basis may need to change to a 1.5 x 1.5m box culvert with a mammal ledge.

4.3.9 A proposed underpass to accommodate a watercourse channel with vehicular and livestock crossing would pass under the highway at Ch 1+350. The underpass would receive flow from the northern cut-off ditch and transfer it to the watercourse to the south of the proposed highway. A physical barrier would be formed in the underpass between the watercourse and future users. The channel would be suitably sized to accommodate the expected peak flows with an additional freeboard allowance.

4.3.10 A proposed 1.2m diameter culvert would pass under the highway at Ch 1+690, conveying the flow from the northern cut-off ditch that

serves the surrounding land to the existing watercourse to the south. It would require a separate ecological crossing beneath the highway.

Catchment C (South of overbridge at Mainline Ch 0+560)

4.3.11 Surface water from the proposed southern section of the B4313 road overbridge and junction would be collected by conventional kerb and gullies and would drain to a low point at Ch 0+400. From here, the proposed drainage infrastructure would discharge surface water to Attenuation/Infiltration Basin C. This would discharge surface water into the adjacent watercourse at GRR.

4.3.12 As the drainage is located within the side road it is proposed that the drainage and basin would be offered for adoption to PCC.

4.3.13 SWTRA drawings show that drainage servicing the existing southern extents of the B4313 connects into the drainage network servicing the existing junction. Due to the highway improvement works the drainage cannot continue to discharge as existing. Therefore, a connection would need to be made to the proposed drainage network and discharge into Basin C.

4.3.14 Where a new drainage system is to be provided, or where an existing drainage network is to connect into the proposed network, the restricted flow would include the 1 in 1 year flow from the existing highway as well as the GRR from the new highway. This would be the basis for calculating the required attenuation volumes.

4.3.15 Due to ecological requirements a proposed 3m x 3m culvert would convey the flow from the aforementioned culvert passing under the main line at Ch 0+440 under the connector road.

Catchment D (North of overbridge at Mainline Ch 0+560)

4.3.16 Surface water from the proposed northern section of the B4313 road overbridge and junction is proposed to be collected by conventional kerb and gullies and would drain to a low point at the tie in to the existing A40 carriageway adjacent to mainline Ch 0+720. From here, the proposed drainage infrastructure would discharge surface water to Attenuation Basin D. This would discharge surface water into the

adjacent watercourse at a controlled rate if required. The Basin would be located within a cutting where the groundwater is expected to be shallow. There may be a risk for groundwater infiltration into the basin . Therefore, if this is the case the basin would need to be lined.

Catchment E (De-trunked road connection to the Penblewin roundabout at Mainline Ch 1+750)

4.3.17 Surface water from the new approach road from the de-trunked A40 to the Penblewin Roundabout is proposed to be drained via conventional kerbs and gullies whilst filter drains would take the flows from the cuttings. The drainage would flow to a low point adjacent to the proposed roundabout at Ch 1+760. From here, the proposed drainage infrastructure would discharge surface water to Attenuation/Infiltration Basin E. This would discharge surface water into the adjacent watercourse at a controlled rate if required.

4.3.18 Basin E is the only basin that receives flows from both the main A40 highway and the side approach road. The side road, along with its drainage would to be adopted by PCC. As the basin receives flow from the A40 it is expected that the basin would be the responsibility of Welsh Ministers as the highway authority.

4.3.19 The drainage from the existing lay-by is to be retained and would need to be accommodated in the new highway design. The existing A40 carriageway to the east of Redstone Cross is to be broken up and the existing drainage can be removed.

Catchment F (Realignment of the existing Redstone Cross junction)

4.3.20 The alignment of the existing Redstone Cross junction is to be adapted. The section of the existing A40 to the west of the junction is to be removed whilst allowing the B4313 to continue northwards.

4.3.21 The existing pavement in the area currently discharges into a local watercourse situated to the south of the junction. This outfall is to be maintained for the re-aligned highway. It is expected that new drainage would be required to service the realigned highway whilst maintaining connection to the current drainage network servicing the B4313 to the north.

4.3.22 SWTRA drawings also show that the outfall services the existing B4313 highway to the south. It is estimated that 340m of the of B4313 is routed through the outfall which would now be routed through Basin C.

4.3.23 The existing A40 carriageway is to be removed, therefore the contributing catchment would be reduced which would provide betterment to the flows even without considering the pavement of the B4313 to the south that is re-routed into Basin C.

Summary

4.3.24 The proposed outfalls and attenuation basin storage volumes are shown in Table 1 below. The information shown is based on preliminary design and may change subject to detailed design.

Table 1 - Attenuation Basin Volume Assessment

Approximate Chainage (m)	Attenuation Basin Outfall	Volume (m^3)	Wet/Dry	Forebay
Ch 0+020	A	1600	Dry	No
Ch 1+300	B	2260	Wet	Yes
Ch 0+310	C	260	Dry	No
Ch 0+780	D	400	Dry	No
Ch 1+750	E	870	Dry	Yes

4.3.25 Vehicular access tracks would be provided to the attenuation/infiltration basins. These would be 3m wide and would be constructed from unbound material.

5 Cross Drainage

5.1.1 Several watercourses/streams cross the route of the proposed Scheme. The flows in these watercourses would be maintained within their catchment through culverts where possible. These cross drainage are designated as ordinary watercourses and will require permitting approval from PCC.

5.1.2 The culverts may require a 150mm embedment for environmental purposes and would be designed in accordance with the requirements of the DMRB HA107/04, CIRIA Report C689 and PCC. The DMRB provides design guidance for the capacity of the culverts based on the surrounding land use. Culverts in urban areas and villages should be designed for 1 in 100 years and agricultural land of high value should be to 1 in 50 years.

5.1.3 The proposed cross drainage culvert at Ch 0 + 440 is near properties and therefore would be designed to convey the 100 year event (+ 30% climate change allowance) flows beneath the proposed highway with an allowance for freeboard of 300mm or a quarter of the diameter, whichever is greater. This return period would need to be agreed with PCC.

5.1.4 All other culverts are located within agricultural land and would be designed for the 50 year + 30% climate change flows due to the purposes of the land use. This return period would need to be agreed with PCC.

5.1.5 Where the catchment area draining to the cross-drainage culvert is not readily defined, the minimum culvert diameter would be 1200mm in accordance with the DMRB. Culvert crossings would be coordinated with the environmental mitigation measures to rationalise/combine crossing points.

5.1.6 Culverts may be upsized to accommodate ecology requirements if necessary.

5.1.7 No main river crossings are required for the proposed Scheme.

5.1.8 Table 2 below indicates the proposed crossing solutions. The culvert sizes shown are to subject to confirmation at the detailed design stage.

Table 2 - Proposed Drainage Crossings

Approximate Culvert Chainage (m)	**Solution**
Ch 0+000	Proposed 0.6m dia. pipe and manhole crossing.
Ch 0+440	2 No. Proposed culverts to cross under proposed A40 and proposed south B4313 connector road.
Ch 0+860	Proposed culvert 1.2m dia. and ecological crossing.
Ch 1+340	Watercourse to pass through proposed underpass. Combined with Farm Access and basin access route.
Ch 1+690	Proposed 0.6m dia. pipe and manhole crossing.

6 Water Quality

6.1.1 Due to the age of the existing highway, it is understood that the existing surface water runoff discharges to the surrounding watercourses, without any pollution prevention measures. No pollution control measures have been encountered on site visits or observed on highway record drawings.

6.1.2 To mitigate the potential impacts of the Scheme on the water environment, a water quality assessment was undertaken in accordance with the best practice detailed in DMRB LA 113 Road Drainage and the Water Environment, and the Highways Agency's Water Risk Assessment Tool (HAWRAT).

6.1.3 The assessment ensures that surface water discharges would not lead to deterioration in the classification status of the receiving surface water bodies and groundwater. The process also assesses the risk of accidental spillage from the Scheme to the receiving environment and considers the management of flood risk.

6.1.4 The HAWRAT assessment identified Catchment B and E as having elevated water quality risk. A forebay is to be incorporated into the basin for both catchments. Additionally, Basin B would need a permanent water level to aid pollutant removal.

7 Elements of High Risk or Complexity

7.1.1 Initial ground investigation indicated that infiltration may be possible for basin A but not for B. Further investigation will be required to determine if and quantify the rate of infiltration for each basin. The difference in size between an infiltration basin and attenuation basin system could be large, and therefore infiltration rates would need to be determined in order to reduce the potential for design change.

7.1.2 There is a risk that the land-take required to meet the storage requirements of the proposed attenuation basins may be higher than anticipated, due to the existing variable topography along the route.

7.1.3 NRW confirmed that a Flood Consequences Assessment (FCA) is not required due to the proposed route being located within flood zone A.

7.1.4 A separate Technical Note has been provided which demonstrates that there is no flooding of third party land in a 1 in 100 year event with 30% allowance for climate change.

7.1.5 On 7th January 2019, the Welsh Government implemented Schedule 3 of the Flood and Water Management Act 2010. All new development of more than one building and/or where the construction area is 100m^2 or more requires sustainable drainage systems (SuDS) for surface water. The SuDS schemes must be approved by the SuDS Approving Body (SAB), before construction work begins.

7.1.6 Although these Statutory Standards apply for developments which include road drainage, they are not to be applied to the trunk road network managed by the Welsh Government. Side roads are not considered trunk roads and would be offered for adoption to the PCC. Therefore, side roads may require SAB approval. However, it is believed that side roads are exempt from the SAB approval process. Achieving SAB approval would require additional effort due to the specific supplementary requirements to attain consent.

Figures

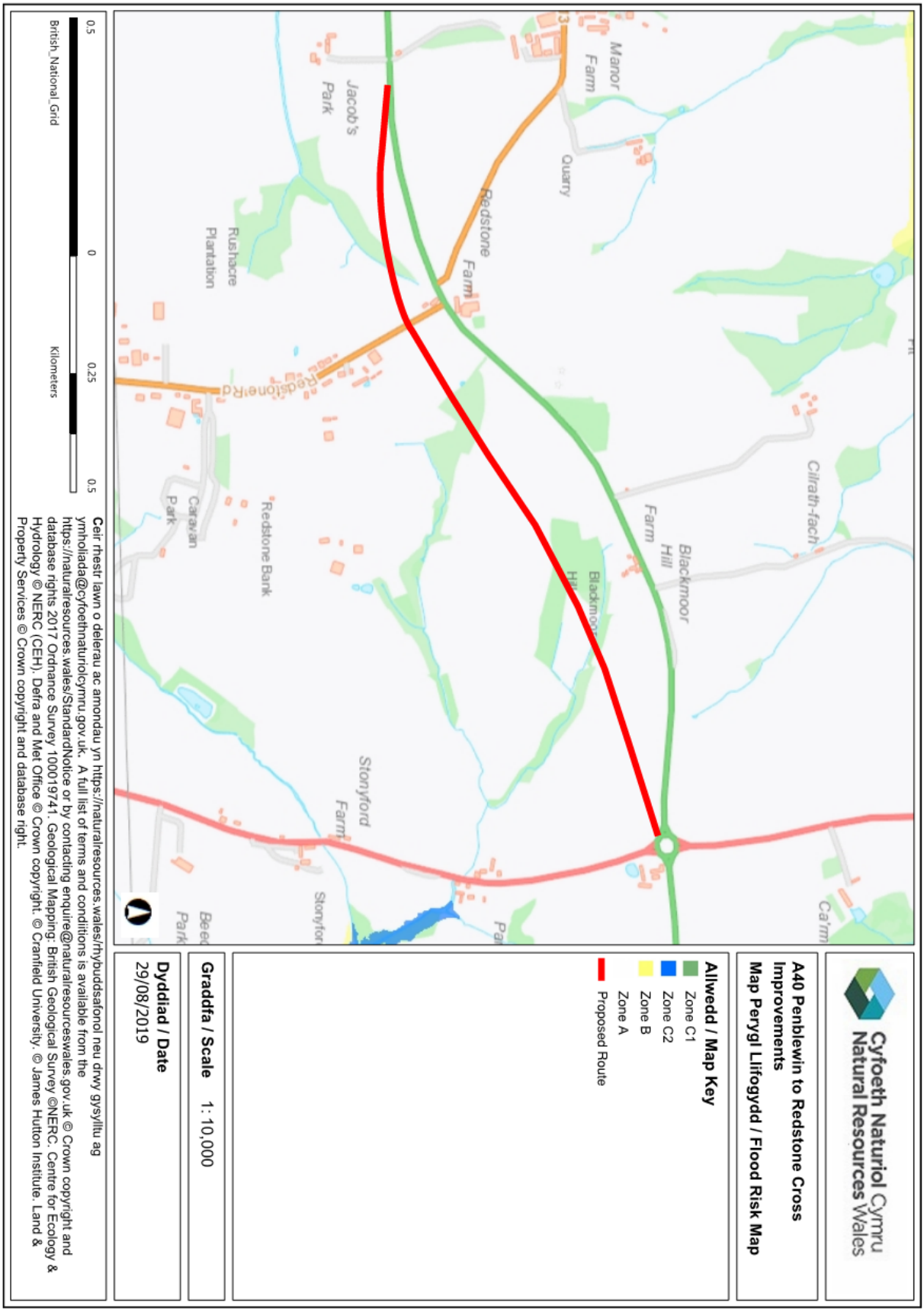

Figure 1 – NRW/TAN 15 Development Advice Map Extract.

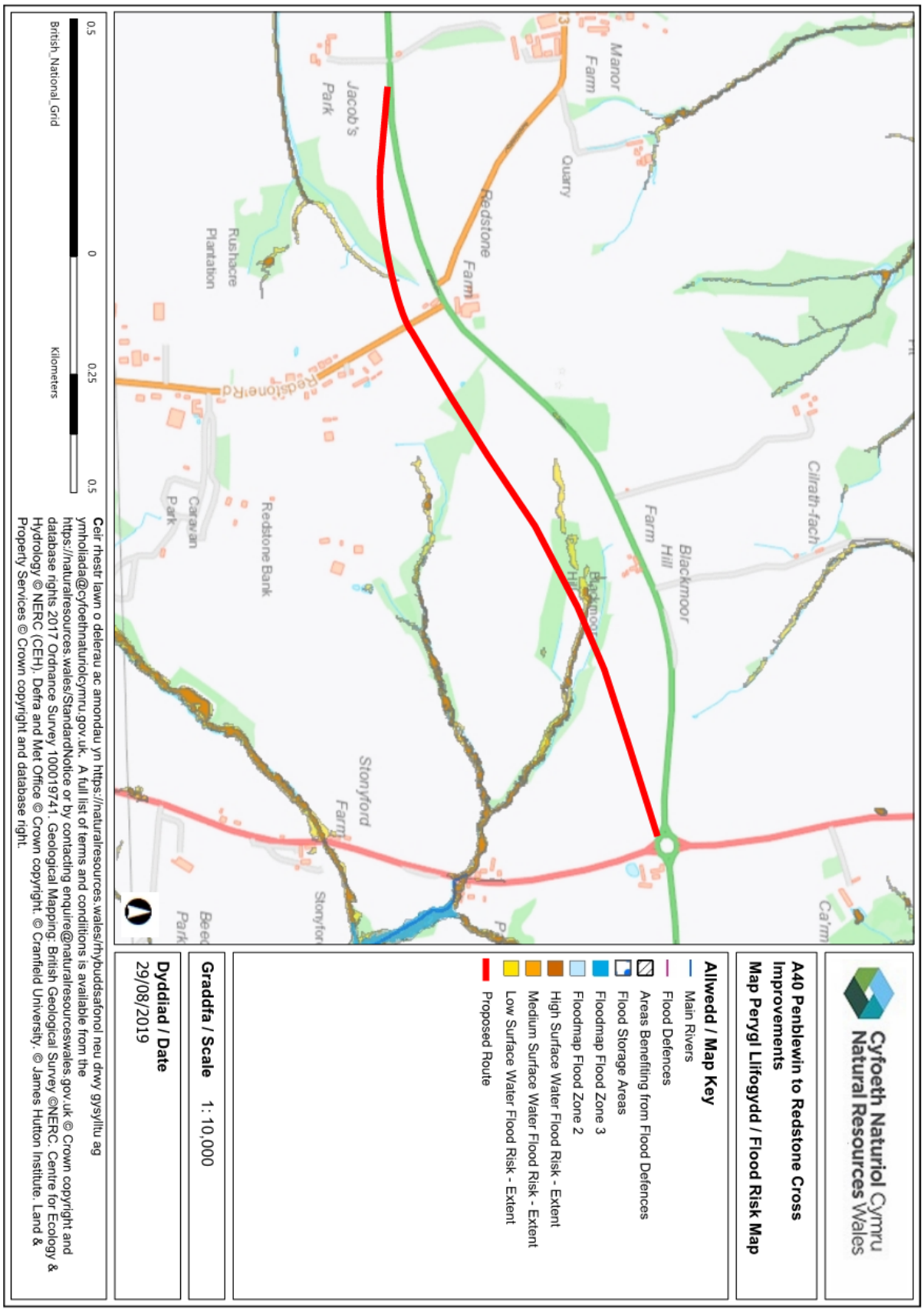

Figure 2 – NRW Flood and Surface Water Risk Map

Appendix A

Stakeholder Correspondence

Aled Roberts

From: SW Planning <swplanning@cyfoethnaturiolcymru.gov.uk>
Sent: 04 November 2019 12:08
To: Aled Roberts
Subject: [External] Penblewin - A40 Penblewin to Redstone Cross (Flood Risk Note) - NRW Response NRW:01260551

Dear Mr Roberts

Thank you for sending through the Flood Risk Note for consultation.

I can confirm that a Flood Consequences Assessment is not required for the proposed development.

However, please provide all calculations and/or modelling in the ES, used to come up with the figures included in section 3.1 (fluvial flooding)

Also in section 3.1 of your note you refer to cross-drainage culverts, please can you include all calculations for the culverts within the ES? and also show calculations for the blockage scenarios of the culverts.

I hope the above comments are of assistance.

Kind Regards
Louise Edwards

Tîm Cynllunio Datblygu / Development Planning Team
Cyfoeth Naturiol Cymru / Natural Resources Wales

Ffôn / Tel: 03000 653573
www.cyfoethnaturiolcymru.gov.uk / www.naturalresourceswales.gov.uk

Yn falch o arwain y ffordd at ddyfodol gwell i Gymru trwy reoli'r amgylchedd ac adnoddau naturiol yn gynaliadwy / Proud to be leading the way to a better future for Wales by managing the environment and natural resources sustainably.

Croesewir gohebiaeth yn Gymraeg a byddwn yn ymateb yn Gymraeg, heb i hynny arwain at oedi / Correspondence in Welsh is welcomed, and we will respond in Welsh without it leading to a delay.

Mike Jones (G)

From: Aled Roberts
Sent: 08 August 2019 16:23
To: Paul.Morgan@pembrokeshire.gov.uk
Cc: Daniel Thomas
Subject: RE: Meeting to discuss A40 drainage

Hi Paul,

I would like to thank you for meeting with us yesterday.

Further to the meeting I would like to confirm that we will be utilising WinFAP 4 and ReFH 2 software to estimate the greenfield runoff rate and the flow within the existing watercourses crossed by the proposed highway.

Also we will be using 30% climate change as part of the drainage design and to size the culverts for the watercourses.

I'll contact again in future if anything arises.

Thank you again for your time,

Aled

From: Aled Roberts
Sent: 02 August 2019 14:10
To: 'Paul.Morgan@pembrokeshire.gov.uk'
Cc: Daniel Thomas
Subject: Meeting to discuss A40 drainage [Filed 02 Aug 2019 14:10]

Hi Paul,

Further to our conversation this morning. I would like to confirm that myself and Dan Thomas will meet with you on Wednesday 7/8/19 at the County Hall in Haverfordwest at 2pm following our site visit.

To aid our discussion please see attached drawing showing the current proposed highway alignment. I have also added some annotation the pdf to show the high point and where the proposed attenuation ponds are to be located.

We look forward to meeting you.

Thanks,

Aled

Aled Roberts
Civl Engineer
MEng (Hons) CEng MICE

Arup
4 Pierhead Street, Capital Waterside, Cardiff CF10 4QP United Kingdom
d: +44 29 2026 6481
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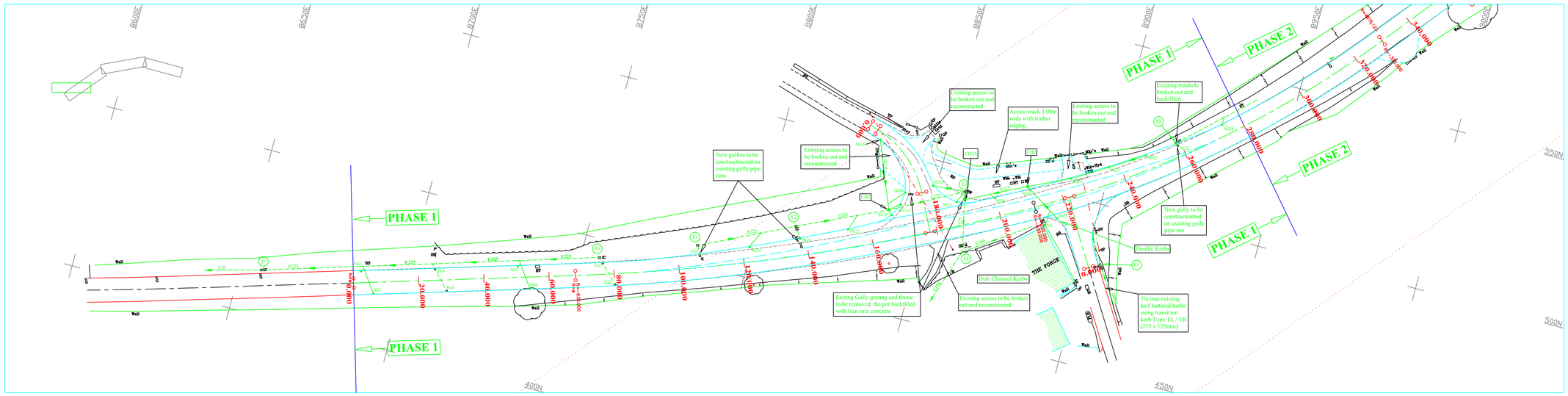
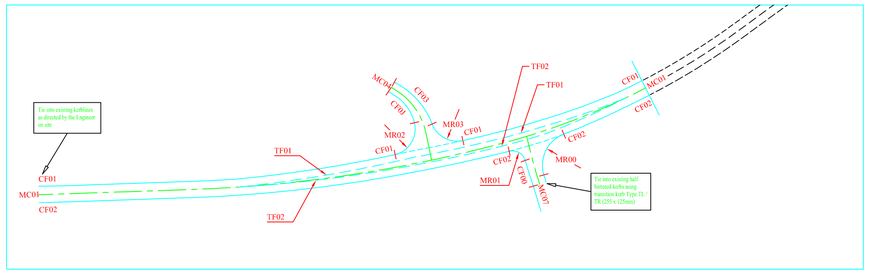
Appendix B

SWTRA Highway Record Drawings

B1 SWTRA Highway Record Drawings



SCHEME PLAN (Phase 1) Scale 1/500



SETTING OUT INFORMATION (Phase 1) Scale 1/1,000

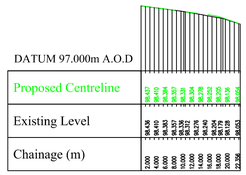
DRAINAGE SCHEDULE

Location		Length (m)	Drain Type	Diameter	Group Number	Depth		Invert Level		Fittings	
From	To					Average	Maximum	Upstream	Downstream	Type	Number
CH2	E3	19.50	CI51	225mm	-	1.100m	1.200m	96.890	96.695	J	1

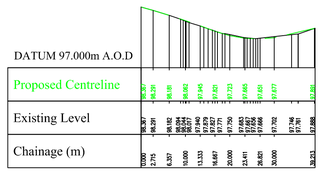
CHAMBER SCHEDULE

Manhole Reference No.	Chainage	Type	Grade of Cover and Frame	Depth	Level		Number of Connections	REMARKS
					Cover	Invert		
E1	100L	Existing	Grade B	581mm	97.767	97.186	2	Renew cover & frame
E2	138L	Existing	Grade B	924mm	97.844	96.920	3	Renew cover & frame
E3	191L	Existing	Grade B	1034mm	97.729	96.695	2(3)	3 new connections (2 x 150mm; 1 x 225mm) new c&f
E4	180R	Existing	Grade B	2700mm	98.089	95.389	3	Renew cover & frame
E5		Existing	Grade B	841mm	98.503	97.662	2	
E6	76L	Existing	Grade B		97.641		2	Renew cover & frame
E7		Existing	Grade B	625mm	95.606	94.981	2	
E8	296L	Existing	Grade B	665mm	97.832	97.167	2	
CH1	166L	Type 1	Grade B	1090mm	97.885	96.795	4	Constructed on existing Carrier Drain
CH2	213L	Type 1	Grade B	1165mm	98.055	96.890	3	

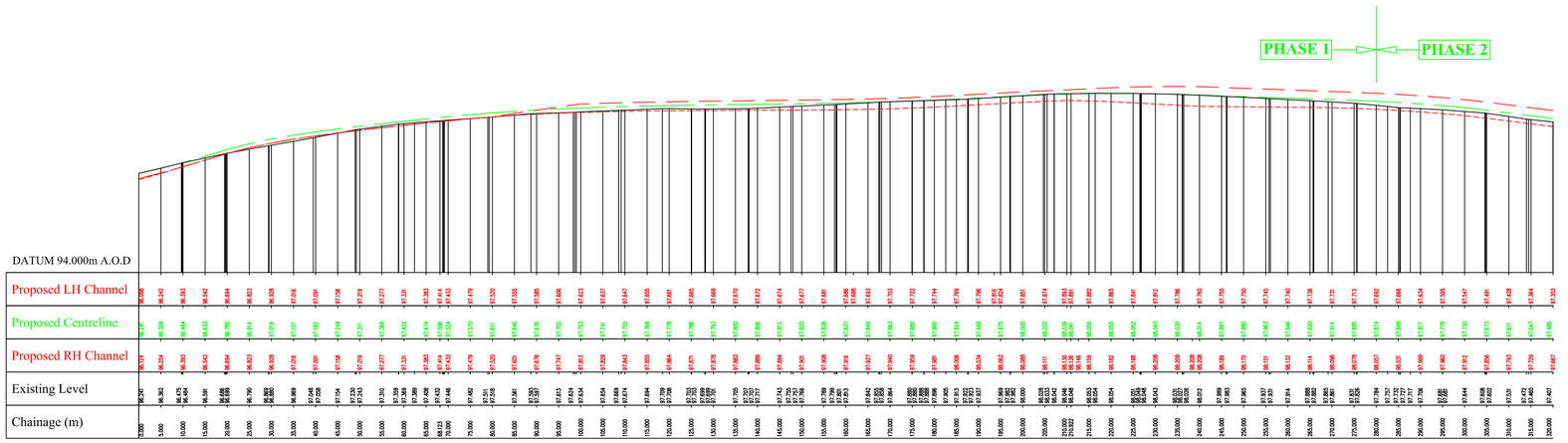
Gully Reference No.	Chainage	Type	Grade of Grating and Frame	Level		Length of Connections	REMARKS
				Cover	Outlet / Invert		
NG1	2.5L	Untrapped	Grade A	96.170	95.420	1.00m	
NG2	5.5R	Untrapped	Grade A	96.268	95.368	9.30m	
EG3	25L	Untrapped	Grade A	96.823*			Renew grating & frame
EG4	28R	Existing	Grade A	96.886*			Renew grating & frame
NG5	51L	Existing	Grade A	97.231	96.481	1.00m	
NG6	54R	Untrapped	Grade A	96.665	95.765	9.30m	
EG7	67L	Existing	Grade A	97.403*			Renew grating & frame
EG8	80R	Existing	Grade A	97.520*			Renew grating & frame
NG9	107L	Untrapped	Grade A	97.643	96.893	2.50m	
NG10	122L	Untrapped	Grade A	97.662	96.912	5.50m	
NG11	138L	Untrapped	Grade A	97.671	96.921	4.00m	Constructed on existing chamber
NG12	153L	Untrapped	Grade A	97.679	96.929	5.00m	
NG13		Untrapped	Grade A	97.658	96.908	2.00m	
NG14		Untrapped	Grade A	97.595	96.845	6.50m	
NG15		Untrapped	Grade A	98.180	97.430	21.50m	
NG16		Untrapped	Grade A	97.576	96.826	9.50m	
NG17		Untrapped	Grade A	97.720	96.970	4.00m	
NG18	200L	Untrapped	Grade A	97.851	97.101	4.00m	
NG19	211L	Type 1 Chamber	Grade A	97.891	97.141	2.00m	Type 1 Chamber as Gully (Depth to invert, 750mm)
NG20	224L	Type 1 Chamber	Grade A	97.846	97.031	13.50m	Type 1 Chamber as Gully (Depth to invert, 835mm)
NG21	256L	Type 1 Chamber	Grade A	97.781	97.151	12.00m	Type 1 Chamber as Gully (Depth to invert, 630mm)
NG22	244L	Type 1 Chamber	Grade A	97.752	97.272	12.00m	Type 1 Chamber as Gully (Depth to invert, 480mm)
NG23	259L	Type 1 Chamber	Grade A	97.749	97.249	1.00m	Type 1 Chamber as Gully (Depth to invert, 500mm)
NG24	274L	Untrapped	Grade A	97.717	97.117	2.00m	Depth to Outlet (invert) 600mm
NG25		Untrapped	Grade A	98.190	97.290	13.00m	



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE - NARBERTH ROAD (MC07)
Scales : Horiz 1/500
Vert 1/50



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE - MAENCLOCHOG ROAD (MC04)
Scales : Horiz 1/500
Vert 1/50



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE (MC01)
Scales : Horiz 1/500
Vert 1/50

NOTES

KEY - Drainage

- E300 — Existing Surface Water Drain (indicating diameter)
- P300 — Proposed Surface Water Drain (indicating diameter)
- E1 — Existing Chamber (See Schedule)
- CH1 — Proposed Chamber (See Schedule)
- NG21 — Proposed Gully
- OG — Existing Gully
- Proposed Connection to existing carrier drain

KEY - Kerbs

SP	Splayed Kerb (Type SP) 125 x 255mm
BN	Bull Nosed Kerb (Type BN) 125 x 150mm
T	Transition Kerb (Types DR / DL)
HB	Half Battered Kerb (Type HB2) 125 x 255mm
2HB	2 No. HB2 kerb units back to back (see detail)

1. All dimensions are in **metres** unless indicated otherwise.
2. The existing surface water system shall be thoroughly cleaned prior to the commencement of the construction phase.
3. All existing gully grating and frames are to be removed. If the gully is to become redundant, it shall be filled with lean mix concrete.
4. New / existing gullies are to be untrapped street gullies (unless specified otherwise) in accordance with HCD Drawing No. F13 with non-rocking captive hinged gully gratings and frames, Type GA1-450.
5. Type 1 Chambers shall be in accordance with HCD Drawing No. F3.
6. All existing covers and frames (manholes, inspection chambers etc) are to be raised / lowered in accordance with the constructions works as detailed in the BofQ.
7. For construction details (Phase 1), see Dwg. No. 4037/DE/005.
8. Detailed setting out information will be furnished to the sucessfull tenderer prior to commencement of the scheme.

Rev.	Amendment	Initials	Date
A.	Kerblines amended as per client request dated 28th July 2000	Made By / Originator / Checked / Approved	V.P 15/8 / V.P 15/8 / /
	"Issued to Tender"	Made By / Originator / Checked / Approved	/ / /

CLIENT
Cyngor Sir Caerfyrddin Carmarthenshire County Council
R.A. SULLY, B.Sc., C.Eng., M.I.C.E., M.I.H.T., M.I.Mgt.
Cyfarwyddwr yr Amgylchedd, *Heol Llansteffan, Tre Ioan Caerfyrddin, Sir Caerfyrddin SA31 3LZ*
Director of Environment, Llanstephan Road, Johnstown, Carmarthen, Carmarthenshire SA31 3LZ

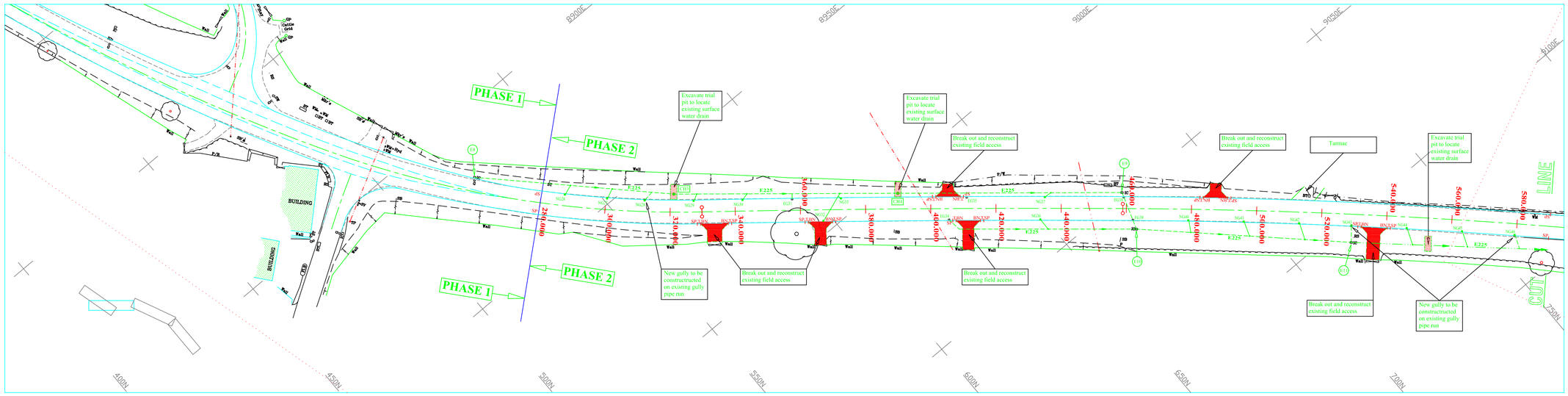
ENGINEER
J.L.REES, B.Sc., C.Eng., M.I.C.E., M.I.L.A.M., M.I.Mgt.
Cyfarwyddwr Gweithrediadau, *Parc Myrddin, Waun Dew, Caerfyrddin, Sir Caerfyrddin SA31 1DS*
Director of Operations, Parc Myrddin, Richmond Terrace, Carmarthen, Carmarthenshire SA31 1DS

PROJECT
LONDON - FISHGUARD TRUNK ROAD A40
Proposed Reconstruction between Penblewin and Redstone Cross

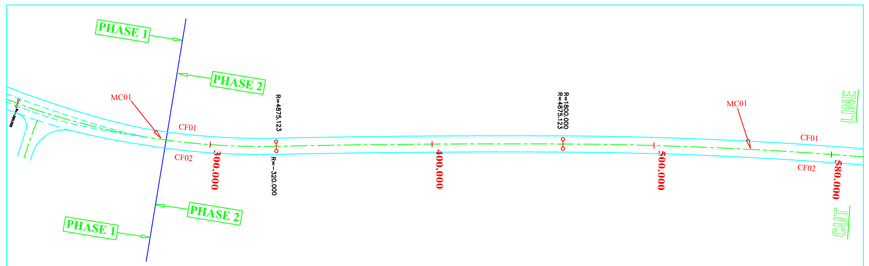
TITLE
SCHEME PLAN (Ch. 0.00 - 280.00m) (Phase 1)

	Initials	Date
Made By	V. Phillips	Oct '99
Originator	V. Phillips	Oct '99
Checked		
Approved		

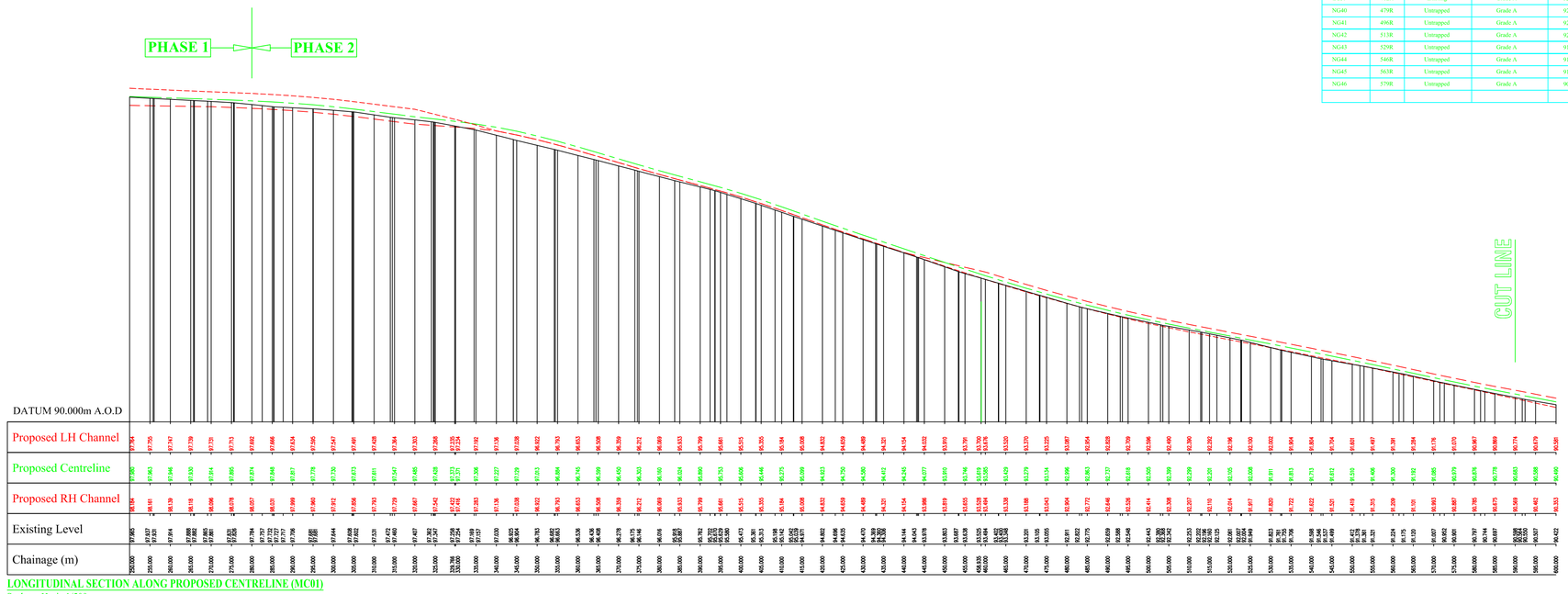
SCALES : As Shown
DRAWING No. 4037/DE/003A AC



SCHEME PLAN (Phase 1) Scale 1/500



SETTING OUT INFORMATION (Phase 1) Scale 1/1,000



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE (MC01)
Scales : Horiz 1/500
Vert 1/50

CHAMBER SCHEDULE

Manhole Reference No.	Chainage	Type	Grade of Cover and Frame	Depth	Level		Number of Connections	REMARKS
					Cover	Invert		
E8	266L	Existing	Grade B	665mm	97.832	97.167	2	
E9	459L	Existing	Grade B	660mm	93.607	92.947	2	Renew cover and frame
E10	463R	Existing	Grade B	1210mm	93.421	92.211	3	Renew cover and frame
E11	529R	Existing	Grade B	1100mm	91.887	90.787	3	Renew cover and frame
CH3	321L	1	Grade B	1950mm	97.823	95.873	2	
CH4	390L	1	Grade B	1570mm	95.985	94.415	2	
CH5	266L	1	Grade B	665mm	97.832	97.167	2	
CH6	166L	1	Grade B	1090mm	97.885	96.795	4	Constructed on existing Carrier Drain
CH7	211L	1	Grade B	1165mm	98.055	96.890	3	

Gully Reference No.	Chainage	Type	Grade of Grating and Frame	Level		Length of Connections	REMARKS
				Cover	Outlet / Invert		
NG26	287L	Untrapped	Grade A	97.653	96.903	3.00m	
NG27	300L	Untrapped	Grade A	97.547	96.797	3.00m	
NG28	312L	Untrapped	Grade A	97.402	96.652		
NG29	327L	Untrapped	Grade A	97.254	96.504	2.00m	
NG30	342L	Untrapped	Grade A	97.097	96.347	2.00m	
EG31	357L	Existing	Grade A	96.737			Renew grating and frame
NG32	367R	Untrapped	Grade A	96.448	95.548	9.50m	
NG33	372L	Untrapped	Grade A	96.300	95.550	1.00m	
EG34	406R	Existing	Grade A	95.321			Renew grating and frame
EG35	411L	Existing	Grade A	95.149			Renew grating and frame
NG36	433R	Untrapped	Grade A	94.388	93.638	3.50m	
NG37	435L	Untrapped	Grade A	94.321	93.571	2.00m	
EG38	459L	Existing	Grade A	93.699			Renew grating and frame
EG39	462R	Existing	Grade A	93.432			Renew grating and frame
NG40	479R	Untrapped	Grade A	92.932	92.182	3.50m	
NG41	496R	Untrapped	Grade A	92.504	91.754	4.00m	
NG42	513R	Untrapped	Grade A	92.168	91.418	4.50m	
NG43	529R	Untrapped	Grade A	91.839	91.089		Invert to match existing gully
NG44	546R	Untrapped	Grade A	91.500		5.12m	Invert to suit existing SW Drain
NG45	563R	Untrapped	Grade A	91.144		4.75m	Invert to suit existing SW Drain
NG46	579R	Untrapped	Grade A	90.805			Invert to match existing gully

NOTES

KEY - Drainage

- E300 — Existing Surface Water Drain (indicating diameter)
- E300 — Existing Surface Water Drain Location & nature undetermined (indicating diameter)
- P300 — Proposed Surface Water Drain (indicating diameter)
- E1 — Existing Chamber (See Schedule)
- CH1 — Proposed Chamber (See Schedule)
- NG01 — Proposed Gully
- EG27 — Existing Gully
- Proposed Connection to existing carrier drain

KEY - Kerbs

- SP — Splayed Kerb (Type SP) 125 x 255mm
- BN — Bull Nosed Kerb (Type BN) 125 x 150mm
- T — Transition Kerb (Types DR / DL)
- HB — Half Battered Kerb (Type HB2) 125 x 255mm
- 2HB — 2 No. HB2 kerb units back to back (see detail)

1. All dimensions are in **metres** unless indicated otherwise.
2. The existing surface water system shall be thoroughly cleaned prior to the commencement of the construction phase.
3. All existing gully grating and frames are to be removed. If the gully is to become redundant, it shall be filled with lean mix concrete.
4. New / existing gullies are to be untrapped street gullies (unless specified otherwise) in accordance with HCD Drawing No. F13 with non-rocking captive hinged gully gratings and frames, Type GA1-450.
5. Type 1 Chambers shall be in accordance with HCD Drawing No. F3.
6. All existing covers and frames (manholes, inspection chambers etc) are to be raised / lowered in accordance with the constructions works as detailed in the BofQ.
7. For construction details (Phase 2), see Dwg. No. 4037/DE/005.
8. Detailed setting out information will be furnished to the sucessfull tenderer prior to commencement of the scheme.

Rev.	Amendment	Initials	Date
		Made By	
		Originator	
		Checked	
		Approved	
	"Issued to Tender"	Made By	
		Originator	
		Checked	
		Approved	

Cyngor Sir Caerfyrddin Carmarthenshire County Council

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Director of Operations, Parc Myrddin, Richmond Terrace, Carmarthen, Carmarthenshire SA31 1DS

PROJECT

LONDON - FISHGUARD TRUNK ROAD A40
Proposed Reconstruction between Penblewin and Redstone Cross

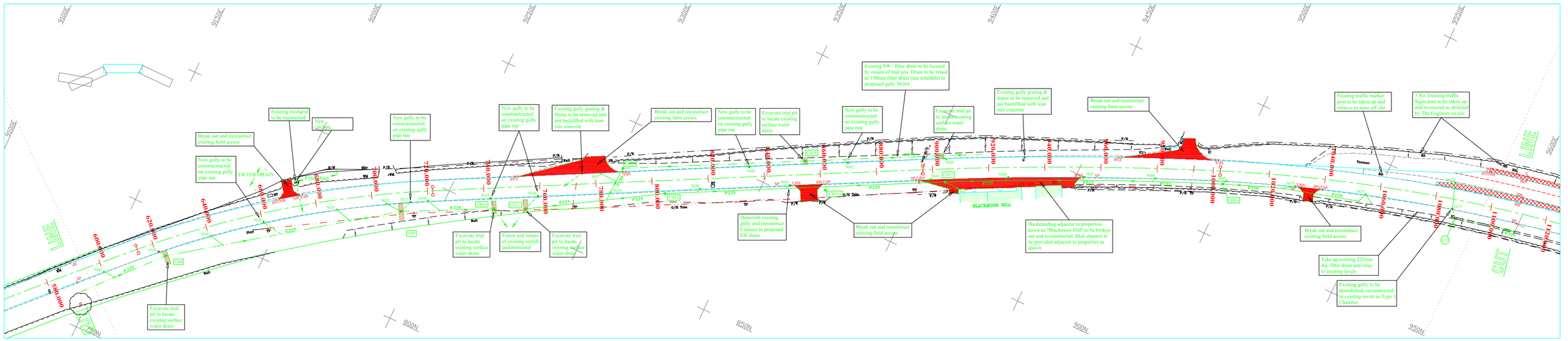
TITLE

SCHEME PLAN (Ch. 280.00 - 590.00m) (Phase 2)

	Initials	Date
Made By	V. Phillips	Oct '99
Originator	V. Phillips	Oct '99
Checked		
Approved		

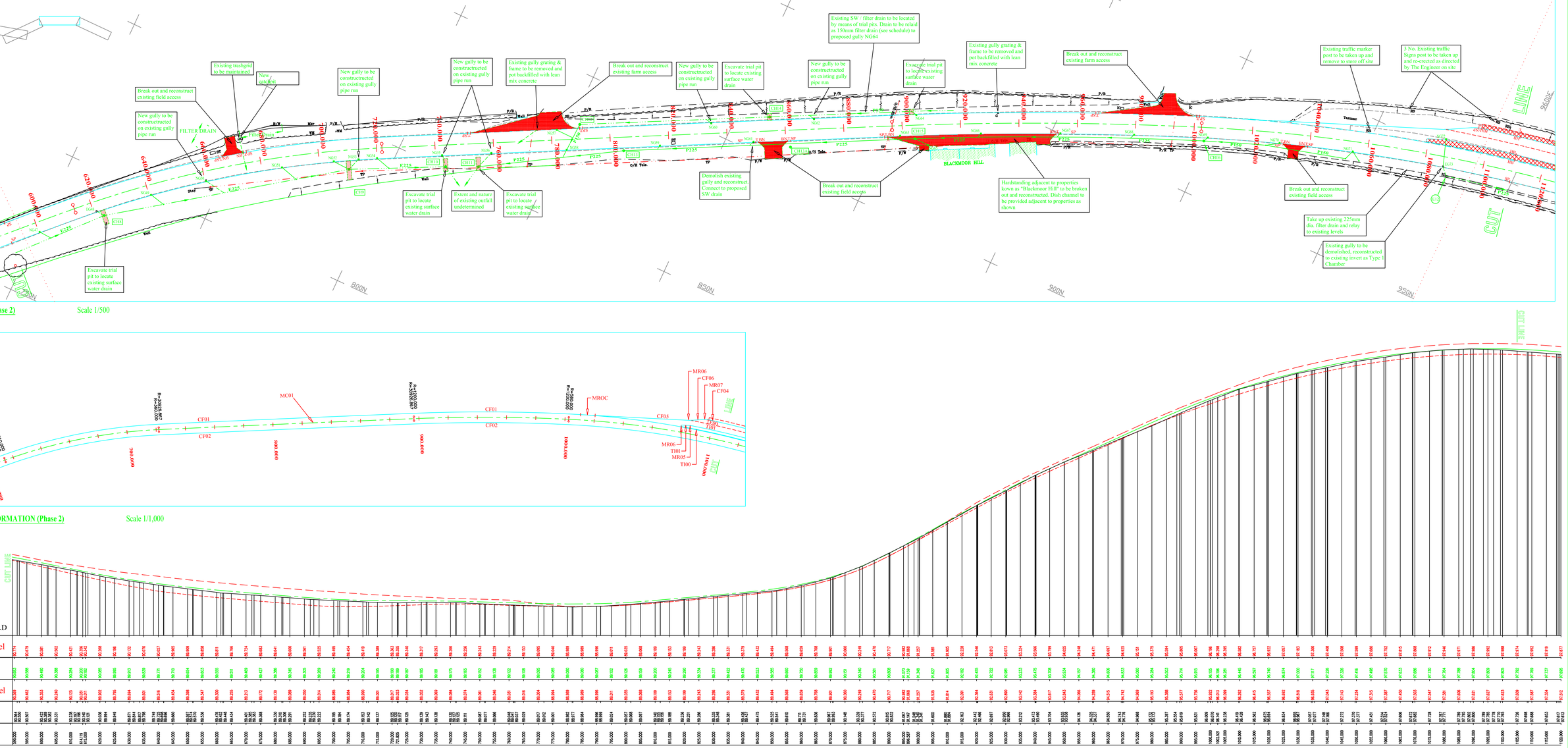
SCALES : As Shown

DRAWING No. 4037/DE/007 T



SCHEME PLAN (Phase 2) Scale 1/500

SETTING OUT INFORMATION (Phase 2) Scale 1/1,000



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE (MC01)
Scales : Horiz 1/500
Vert 1/50

NOTES

1. All dimensions are in **metres** unless indicated otherwise.
2. The existing surface water system shall be thoroughly cleaned prior to the commencement of the construction phase.
3. All existing gully grating and frames are to be removed. If the gully is to become redundant, it shall be filled with lean mix concrete.
4. New / existing gullies are to be untrapped street gullies (unless specified otherwise) in accordance with HCD Drawing No. F13 with non-rocking captive hinged gully gratings and frames, Type GA1-450.
5. Type 1 / 3 / 7 Chambers shall be in accordance with the HCD Standard Drawings.
6. All existing covers and frames (manholes, inspection chambers etc) are to be raised / lowered in accordance with the constructions works as detailed in the BofQ.
7. The proposed layby is to be constructed in accordance with that set out in **DMRB Vol. 6, Sect. 3, Pt. 3 (TA 69/96),** Type A.
8. For construction details (Phase 2), see Dwg. No. 4037/DE/005.
9. Detailed setting out information will be furnished to the sucessfull tenderer prior to commencement of the scheme.

KEY - Drainage

- E300 — Existing Surface Water Drain (indicating diameter)
- E300 — Existing Surface Water Drain Location & nature undetermined (indicating diameter)
- P300 — Proposed Surface Water Drain (indicating diameter)
- E1 — Existing Chamber (See Schedule)
- CH1 — Proposed Chamber (See Schedule)
- NGH — Proposed Gully
- NG1 — Existing Gully
- Proposed Connection to existing carrier drain

KEY - Kerbs

SP	Splayed Kerb (Type SP) 125 x 255mm
BN	Bull Nosed Kerb (Type BN) 125 x 150mm
T	Transition Kerb (Types DR / DL)
HB	Half Battered Kerb (Type HB2) 125 x 255mm
Y	Transition Kerb (Types TR / TL)
D	Dish Channel (Type CD) 255 x 125mm
E	Edging Kerb (Type EF) 150 x 50mm

DRAINAGE SCHEDULE

Location From	Location To	Length (m)	Drain Type	Diameter	Gauge Number	Depth Average	Depth Maximum	Invert Level Upstream	Invert Level Downstream	Fittings Type	Fittings Number
NG58	CH12	9.50	C(Z)	150mm	-	0.650m	0.690m	88.484	88.389	J	1
CH12	CH14	65.00	F(G)	150mm	-	0.700m	0.740m	89.004	88.484	J	1
CH14	Connection	49.00	F(G)	150mm	-	0.766m	0.800m	90.579	89.004	J	1
CH11	CH13	50.00	C(S)	225mm	-	0.900m	1.065m	88.504	88.170	J	1
CH13	CH13A	55.00	C(S)	225mm	-	1.100m	1.200m	88.868	88.504	J	2
CH13A	CH15	45.00	C(S)	225mm	-	1.100m	1.200m	90.600	88.868	J	1
CH15	CH16	100.00	C(S)	225mm	-	1.100m	1.200m	95.255	90.600	J	3
CH16	Connection	26.00	C(S)	150mm	-	1.100m	1.200m	96.068	95.255	J	1

CHAMBER SCHEDULE (MANHOLE / CATCHPIT)

Manhole Refrence No.	Chainage	Type	Grade of Cover and Frame	Depth	Level Cover	Level Invert	Number of Connections	REMARKS
CH8	623R	Type 1	Grade B		90.013		3	To be constructed on Existing SW Drain
CH9	710R	Type 1	Grade B		89.165		3	To be constructed on Existing SW Drain
CH10	743R	Type 7	Grade B		89.253		3	To be constructed on Existing SW Drain
CH11	754R	Type 7	**Grade B**	1055mm	89.225	88.170	3	
CH12	790L	Type 1	Grade B	690mm	89.174	88.484	2	
CH13	805R	Type 1	**Grade B**	740mm	89.244	88.504	2	
CH13A	860R	Type 1	**Grade B**	970mm	89.838	88.868	2	
CH14	855L	Type 1	Grade B	740mm	89.744	89.004	2	
CH15	904R	Type 1	**Grade B**	960mm	91.560	90.600	3	
CH16	1004R	Type 1	**Grade B**	995mm	96.250	95.255	3	
E12	1088L	Existing	Grade B	680mm	97.641	96.961	3	

CHAMBER SCHEDULE (GULLY)

Gully Refrence No.	Chainage	Type	Grade of Grating and Frame	Level Cover	Level Outlet / Invert	Length of Connections	REMARKS
NG47	600R	Untrapped	Grade A	90.353		4.00m	Invert / outlet to suit existing SW Drain
EG48	621R	Existing	Grade A	89.881	As Existing		Renew grating and frame
NG49	641R	Untrapped	Grade A	89.504		5.00m	Invert / outlet to suit existing SW Drain
NG50	661R	Untrapped	Grade A	89.291	As Existing		Construct new gully on existing gully pipe run
NG51	687R	Untrapped	Grade A	89.081		6.00m	Invert / outlet to suit existing SW Drain
NG52	705R	Untrapped	Grade A	88.984		5.00m	Invert / outlet to suit existing SW Drain
NG53	713R	Untrapped	Grade A	88.997	As Existing		Construct new gully on existing gully pipe run
NG54	729R	Untrapped	Grade A	89.017		5.00m	Invert / outlet to suit existing SW Drain
NG55	742R	Untrapped	Grade A	89.080	As Existing		Construct new gully on existing gully pipe run
NG56	759R	Untrapped	Grade A	89.034	As Existing		Construct new gully on existing gully pipe run
NG57	782L	Untrapped	Grade A	88.988	88.588	6.00m	600mm deep
NG58	785R	Untrapped	Grade A	88.989	88.389	2.50m	600mm deep
NG59	817R	Untrapped	Grade A	89.171	88.571	1.50m	600mm deep
NG60	834L	Untrapped	Grade A	89.322	88.872	1.50m	450mm deep
NG61	849R	Untrapped	Grade A	89.482	88.832	1.50m	650mm deep
NG62	870L	Untrapped	Grade A	89.901	89.151	1.50m	
NG63	899R	Untrapped	Grade A	91.219	90.469	1.50m	
NG64	905L	Untrapped	Grade A	91.581	90.831	1.50m	
NG65	909R	Untrapped	Grade A	91.758	91.008	1.50m	
NG66	927R	Untrapped	Grade A	92.735	91.985	1.50m	
NG67	954R	Untrapped	Grade A	94.021	93.271	1.50m	
NG68	979R	Untrapped	Grade A	95.148	94.398	1.50m	
NG69	1005R	Untrapped	Grade A	96.099	95.349	1.50m	
NG70	1030R	Type 1 chamber	Grade A	96.818	96.068	5.00m	
NG71	1055R	Type 1 Chamber	Grade A	97.335		3.50m	Invert / outlet to suit existing SW Drain
NG72	1086L	Untrapped	Grade A	98.026		9.25m	Invert / outlet to suit existing gully NG73
EG73	1087R	Existing	Grade A	97.612		3.20m	Reconstruct as Type 1 Chamber

		Made By	
	"Issued to Tender"	Originator	
		Checked	
		Approved	

Rev.	Amendment	Initials	Date

CLIENT
Cyngor Sir Gaerfyrddin Carmarthenshire County Council

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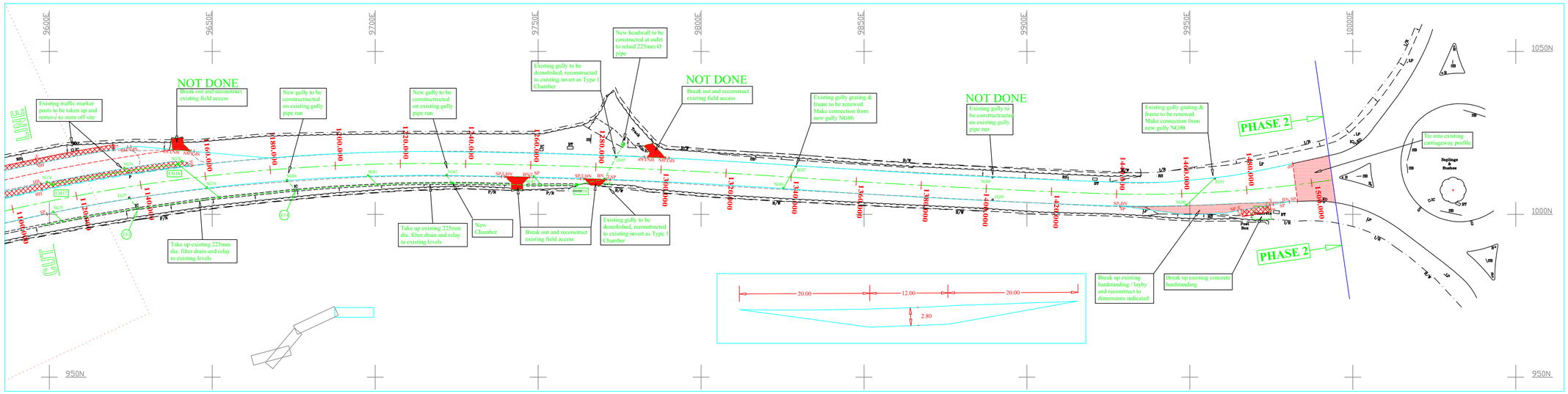
PROJECT
LONDON - FISHGUARD TRUNK ROAD A40
Proposed Reconstruction between Penblewin and Redstone Cross

TITLE
SCHEME PLAN (Ch. 590.00 - 1110.00m) (Phase 2)

	Initials	Date
Made By	V. Phillips	Nov' 99
Originator	V. Phillips	Nov' 99
Checked		
Approved		

SCALES : As Shown

DRAWING No. 4037/DE/008 T



SCHEME PLAN (Phase 2) Scale 1/500

SETTING OUT INFORMATION (Phase 2) Scale 1/1,000

DRAINAGE SCHEDULE

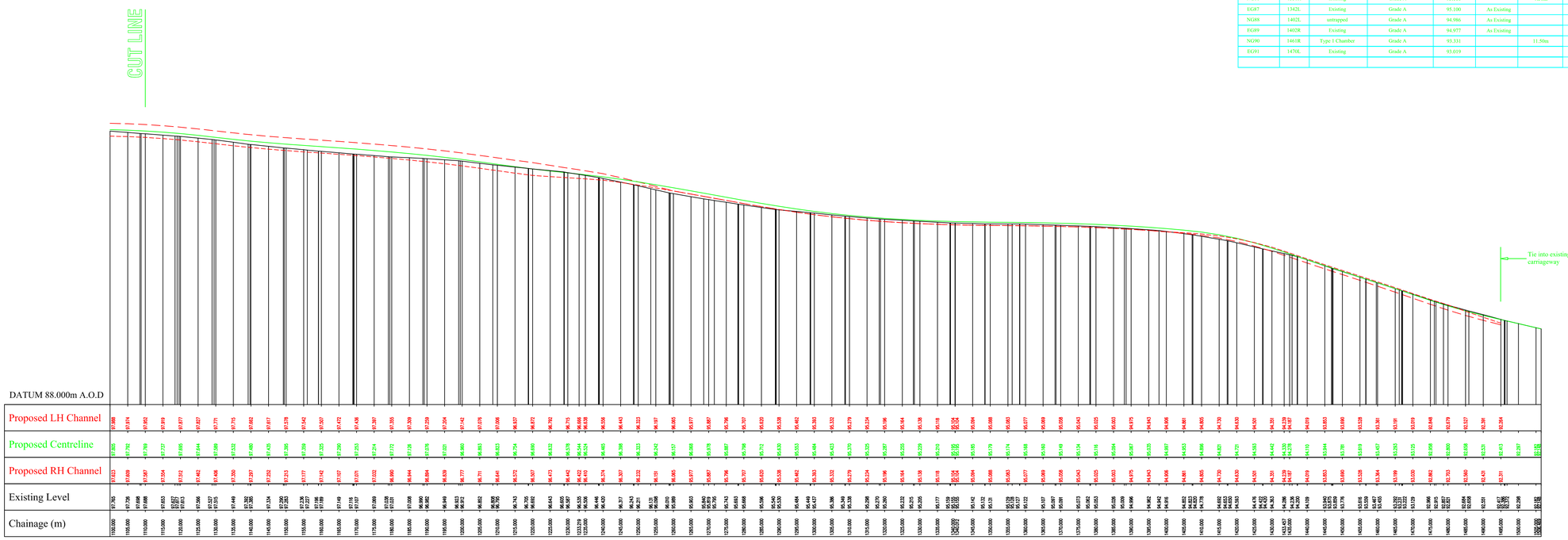
Location From	Location To	Length (m)	Drain Type	Diameter	Group Number	Depth Average	Depth Maximum	Invert Level Upstream	Invert Level Downstream	Fittings Type	Fittings Number
CH17	CH18	39.00	C(S)	150mm	-	1.000m	1.050m	97.015	96.705	J	1
CH18	NG79	11.00	C(Z)	150mm	-	0.750m	1.000m	96.705	96.592		
E12	E13	49.00	F(G)	225mm	-	0.650m	0.700m	96.961	96.744	J	2
E13	E14	49.00	F(G)	225mm	-	0.625m	0.650m	96.744	96.352	J	1
E14	CH19	86.50	F(G)	225mm	-	0.825m	1.100m	96.352	94.960	J	2
CH19	EG84	8.50	C(S)	225mm	-	1.000m	1.100m	94.860	94.772		
EG84	EG85	7.50	C(Z)	225mm	-	0.950m	1.100m	94.772	94.602		
EG85	Headwall	3.50	C(S)	225mm	-	0.750m	1.100m	94.602	94.450		

CHAMBER SCHEDULE (MANHOLE / CATCHPIT)

Manhole Reference No.	Chainage	Type	Grade of Cover and Frame	Depth	Level Cover	Level Invert	Number of Connections	REMARKS
E13	1134R	Existing	Grade B	630mm	97.374	96.744	3	
E14	1187R	Existing	Grade B	630mm	96.982	96.352	3	
CH17	1113L	Type 1	Grade B	1050mm	98.065	97.015	2	
CH18	1152L	Type 1	Grade B	990mm	97.695	96.705	3	
CH19	1274R	Type 7	Grade B	1270mm	95.830	94.560	2	

CHAMBER SCHEDULE (GULLY)

Gully Reference No.	Chainage	Type	Grade of Grating and Frame	Level Cover	Level Outlet / Invert	Length of Connections	REMARKS
NG74	1112L	Untrapped	Grade A	97.974	97.224	1.50m	In Layby
NG75	1112R	Type 1 Chamber	Grade A	97.556	96.906	4.50m	650mm deep
NG76	1136L	Untrapped	Grade A	97.757	97.007	1.50m	In Layby
EG77	1136R	Existing	Grade A	96.170	As Existing		New Grating & Frame
NG78	1153L	Untrapped	Grade A	97.567	96.817	1.00m	In Layby
NG79	1160R	Type 1 Chamber	Grade A	97.142	96.592	5.00m	550mm deep
NG80	1185R	Type 1 Chamber	Grade A	96.944	As Existing		New gully constructed on existing line
NG81	1210R	Type 1 Chamber	Grade A	97.641	95.991	4.00m	650mm deep
NG82	1234R	Type 1 Chamber	Grade A	96.416	As Existing		New gully constructed on existing line
NG83	1261R	Untrapped	Grade A	96.047	95.297	3.50m	
EG84	1283R	Type 1 Chamber	Grade A	95.672	94.772	8.50m	Existing gully reconstructed as T1 chamber (225mm Ø)
EG85	1296L	Type 1 Chamber	Grade A	95.602	94.602	3.50m	Existing gully reconstructed as T1 chamber (225mm Ø)
NG86	1338R	Existing	Grade A	95.110		7.50m	Invert to suit connection to NG87
EG87	1342L	Existing	Grade A	95.100	As Existing		New Grating & Frame
NG88	1402L	untrapped	Grade A	94.986	As Existing		New gully constructed on existing line
EG89	1402R	Existing	Grade A	94.977	As Existing		New Grating & Frame
NG90	1461R	Type 1 Chamber	Grade A	93.331		11.50m	Invert to suit connection to NG91
EG91	1470L	Existing	Grade A	93.019			New Grating & Frame



LONGITUDINAL SECTION ALONG PROPOSED CENTRELINE (MC01)
Scales : Horiz 1/500
Vert 1/50

NOTES

KEY - Drainage

- E300 — Existing Surface Water Drain (indicating diameter)
- P300 — Proposed Surface Water Drain (indicating diameter)
- E1 — Existing Chamber (See Schedule)
- CH01 — Proposed Chamber (See Schedule)
- MH21 — Proposed Gully
- EG22 — Existing Gully
- Proposed Connection to existing carrier drain

KEY - Kerbs

- SP — Splayed Kerb (Type SP) 125 x 255mm
- BN — Bull Nosed Kerb (Type BN) 125 x 150mm
- T — Transition Kerb (Types DR / DL)
- HB — Half Battered Kerb (Type HB2) 125 x 255mm
- Y — Transition Kerb (Types TR / TL)
- D — Dish Channel (Type CD) 255 x 125mm
- E — Edging Kerb (Type EF) 150 x 50mm

NOTES

1. All dimensions are in **metres** unless indicated otherwise.
2. The existing surface water system shall be thoroughly cleaned prior to the commencement of the construction phase.
3. All existing gully grating and frames are to be removed. If the gully is to become redundant, it shall be filled with lean mix concrete.
4. New / existing gullies are to be untrapped street gullies (unless specified otherwise) in accordance with HCD Drawing No. F13 with non-rocking captive hinged gully gratings and frames, Type GA1-450.
5. Type 1 / 3 / 7 Chambers shall be in accordance with the HCD Standard Drawings.
6. All existing covers and frames (manholes, inspection chambers etc) are to be raised / lowered in accordance with the constructions works as detailed in the BofQ.
7. The proposed layby is to be constructed in accordance with that set out in **DMRB Vol. 6, Sect. 3, Pt. 3 (TA 69/96),** Type A.
8. For construction details (Phase 2), see Dwg. No. 4037/DE/005.
9. Detailed setting out information will be furnished to the sucessfull tenderer prior to commencement of the scheme.

	Made By		
	Originator		
	Checked		
	Approved		
	Made By		
	Originator		
	Checked		
"Issued to Tender"	Approved		

Rev.	Amendment	Initials	Date

CLIENT
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Director of Operations, Parc Myrddin, Richmond Terrace, Carmarthen, Carmarthenshire SA31 1DS

PROJECT
LONDON - FISHGUARD TRUNK ROAD A40
Proposed Reconstruction between Penblewin and Redstone Cross

TITLE
SCHEME PLAN (Ch. 1110.00 - 1506.469m) (Phase 2)

	Initials	Date
Made By	V. Phillips	Dec' 99
Originator	V. Phillips	Dec' 99
Checked		
Approved		

SCALES : As Shown
DRAWING No. 4037/DE/009 T

DO NOT SCALE

Millimetres 0 10 100

2m LENGTH OF 225Ø PIPE TO BE REPLACED INCLUDING 150Ø GULLY CONNECTION. LOCATION = 9.7m EAST OF MH-SW20. DEPTH TO INVERT 1.2m.

2m LENGTH OF 225Ø PIPE TO BE REPLACED INCLUDING 150Ø GULLY CONNECTION. LOCATION = 17m WEST OF MH-SW18. DEPTH TO INVERT 1m.

10m LENGTH OF 225Ø PIPE TO BE REPLACED INCLUDING 150Ø GULLY CONNECTION. LOCATION = 20m EAST OF MH-SW18. DEPTH TO INVERT 1m.

3m LENGTH OF 150Ø PIPE TO BE REPLACED AND CONNECTED TO MH-SW13. DEPTH TO INVERT 1.25m

4m LENGTH OF 150Ø PIPE TO BE REPLACED INCLUDING CONNECTION TO 225Ø PIPE. DEPTH TO INVERT 1.25m

2m LENGTH OF 225Ø PIPE TO BE REPLACED INCLUDING CONNECTION TO 150Ø PIPE. DEPTH TO INVERT 1.15m. LOCATION = 11.7m WEST OF MH-SW12.

2m LENGTH OF 225Ø PIPE TO BE REPLACED INCLUDING CONNECTION TO 150Ø PIPE. LOCATION = 30.9m WEST OF MH-SW12.

6m LENGTH OF 150Ø PIPE TO BE REPLACED INCLUDING 2m LENGTH OF 225Ø PIPE AND CONNECTION. DEPTH TO INVERT 1.2m.

6m LENGTH OF 150Ø PIPE TO BE REPLACED INCLUDING 2m LENGTH OF 255Ø PIPE AND CONNECTION. DEPTH TO INVERT 1.2m

1m LENGTH OF 255Ø PIPE AND CONNECTION TO 150Ø TO BE REPLACED. LOCATION 26m EAST OF MH-SW11.

1m LENGTH OF 150Ø PIPE TO BE REPLACED LOCATION 3.6m FROM G21.

2m LENGTH OF 150Ø PIPE TO BE REPLACED. LOCATION 3m FROM GULLY.

90m LENGTH OF 225Ø CARRIER PIPE REPLACED WITH 300Ø CARRIER PIPE.

3m LENGTH OF 150Ø PIPE TO BE REPLACED LOCATION 2.8m FROM GULLY.

NEW 143m LENGTH OF DITCH TO BE CONSTRUCTED. REFER TO STANDARD DETAIL DRAWING NO. AR03-004-ATK-HGN-SWTRA-DR-D-0004

150Ø FILTER DRAIN TO BE CAPPED WHERE IT CLASHES WITH PROPOSED DRAINAGE .

TEMPORARY VEGETATION CLEARANCE. REFER TO NOTE 3.

NEW HW2 HEADWALL AND 225Ø CONNECTION TO NEW TYPE 7 CATCHPIT SW17A.

SW-17a NEW CATCHPIT HCD TYPE 7.

NEW HW1 HEADWALL AND 225Ø CONNECTION TO MH-SW17.

AREA OF PONDING WATER.

CAP END

MH-SW17

FOR CONTINUATION SEE BELOW

SEE INSET A

EXISTING MANHOLE TO BE REPLACED WITH NEW CATCHPIT HCD TYPE 7 WITH GULLY GRATING.

NEW 7.5m LENGTH 225Ø CARRIER PIPE CROSS ACCESS FIELD CONNECTION.

NEW GULLY AND 12m LENGTH OF 150Ø PIPE.

2m LENGTH OF 150Ø PIPE TO BE REPLACED UNDER CRASH BARRIER. BARRIER POST TO BE RESET.

TO REDSTONE CROSS

TO PLENBLEWIN

MH-SW20 MH-SW19 MH-SW18 MH-SW21 MH-SW13 MH-SW14 MH-SW12 MH-SW10 MH-SW11 MH-SW8

G37 G38 G39 G40 G41 G42 G31 G32 G30 G29 G28 G27 G26 G25 G24 G23 G22 G21 G20 G19 G18 G17 G16

225Ø FD 225Ø CD 150Ø CD

INSET A
SCALE 1:250

ACCESS TRACK TO BE RE-SURFACED TO REMOVE PONDING AREA

76m LENGTH OF 225Ø FILTER DRAIN REPLACED WITH 300Ø FILTER DRAIN AT A NEW GRADIENT.

38m LENGTH OF 225Ø FILTER DRAIN REPLACED WITH 300Ø CARRIER DRAIN AT A NEW GRADIENT.

24m LENGTH OF 225Ø CARRIER PIPE REPLACED WITH 300Ø CARRIER PIPE .

SW17-b NEW CATCHPIT HCD TYPE 7.

EXISTING MANHOLE TO BE REPLACED WITH NEW CATCHPIT HCD TYPE 7.

65m LENGTH OF 150Ø FILTER DRAIN REPLACED WITH 225Ø FILTER DRAIN.

REPLACE WITH CATCHPIT HCD TYPE 7

50m LENGTH OF 150Ø FILTER DRAIN REPLACED WITH 225Ø FILTER DRAIN.

FOR CONTINUATION SEE ABOVE

2m LENGTH OF 150Ø PIPE TO BE REPLACED.

2m LENGTH OF 150Ø PIPE TO BE REPLACED UNDER BARRIER. BARRIER POST TO BE RESET.

10m LENGTH OF 225Ø PIPE REPLACED WITH 450Ø PIPE.

45m LENGTH OF 225Ø PIPE REPLACED WITH 450Ø AT A NEW GRADIENT.

22m LENGTH OF 375Ø PIPE REPLACED WITH 450Ø PIPE.

NEW 150Ø GULLY CONNECTION.

NEW 12m 300Ø CROSS CARRIAGEWAY CONNECTION.

SW16a NEW CATCHPIT HCD TYPE 7.

TEMPORARY VEGETATION CLEARANCE. REFER TO NOTE 3.

NEW HEADWALL FOR OUTFALL TO DITCH.

DITCH TO BE CLEARED TO FIELD BOUNDARY, APPROX. 100m.

MH-SW16 MH-SW15 MH-SW9 MH-SW7 MH-SW6 MH-SW5 MH-SW4 MH-SW3 MH-SW2 MH-SW1

G36 G35 G34 G33 G16 G15 G14 G13 G12 G11 G10 G9 G8 G7 G6 G5 G4 G3 G2 G1

ACO-DRAIN

Little Meadow

Blackmoor Hill

KEY

G34 □	EXISTING GULLY	——— - ———	EXISTING FILTER DRAIN (WITH DIAMETER AND FLOW DIRECTOR)
MH-SW ●	EXISTING MANHOLE	——— · ———	EXISTING CARRIER DRAIN (WITH DIAMETER AND FLOW DIRECTOR)
MH-SW ●	PROPOSED CATCHPIT	———	PROPOSED MAINTENANCE WORKS
HW ⊃	HEADWALL	- - - - - -	PROPOSED DITCH
G34 □	PROPOSED GULLY	——— – ———	PROPOSED IMPROVEMENT SCHEME FILTER DRAIN
		——— · ———	PROPOSED IMPROVEMENT SCHEME CARRIER DRAIN

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GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. TEMPORARY EXCAVATED PLANTS/SHRUBS TO BE PRESERVED AND REPLANTED ON CONSTRUCTION WORK COMPLETION. REPLANTING TO BE DONE TO BEST MATCH ITS ORIGINAL LOCATION. CARE MUST BE TAKEN TO AVOID CLASH WITH EXISTING SERVICES AND NEW BUILT CONSTRUCTION.
4. DRAWING SHALL BE READ IN CONJUNCTION WITH STANDARD DETAIL DRAWING No. AR03-004-ATK-HGN-SWTRA-DR-D-0003.
5. WHERE IT'S PROPOSED TO UPSIZE EXISTING DRAINAGE PIPES UPSTREAM AND DOWNSTREAM MANHOLES TO BE MODIFIED TO FIT PROPOSED PIPE OR REPLACED IF REQUIRED. ALL INCOMING PIPES AFFECTED BY WORK TO BE RE-CONNECTED.
6. ALL PIPES PROPOSED TO BE UP-SIZED TO BE REPLACED SOFFIT TO SOFFIT UNLESS OTHERWISE STATED.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

CONSTRUCTION

PROXIMITY TO HIGH SPEED TRAFFIC

MAINTENANCE/CLEANING

N/A

DECOMMISSIONING/DEMOLITION

N/A

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

Rev.	Date	Description	By	Chk'd	App'd
P1	23/02/2017	FIRST ISSUE	M.C.	A.A.	A.R.

Drawing Status: FOR INFORMATION

Suitability: S0

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Client: Yn gweithio ar ran **Llywodraeth Cymru** Working on behalf of the **Welsh Government**

Project Title: A40 EAST OF REDSTONE CROSS NEAR NARBERTH

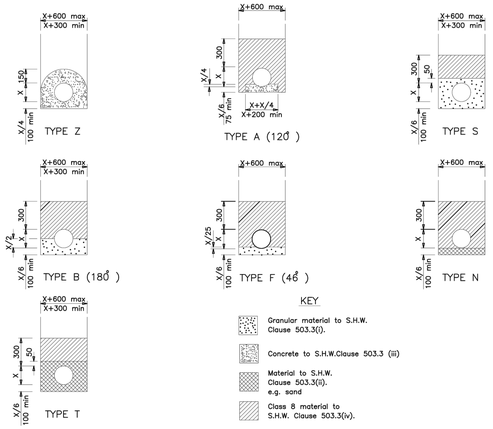
Drawing Title: DRAINAGE MAINTENANCE AND IMPROVEMENT WORKS

Scale	Designed	Drawn	Checked	Authorised
1:2500	A.A.	M.C.	A.A.	A.R.
Original Size	**Date**	**Date**	**Date**	**Date**
A1	23/02/17	23/02/17	23/02/17	23/02/17

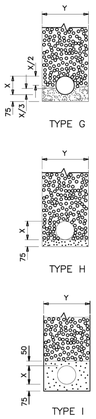
Drawing Number: AR03-004-ATK-HGN-SWTRA-DR-D-0002

Revision: P1

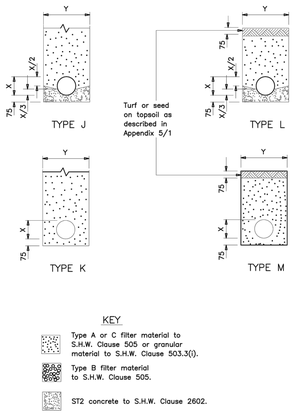
DO NOT SCALE



NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. This drawing is to be read in conjunction with Appendix 5/1
3. Dimension X is the external diameter of the pipe.
4. The minimum or maximum width of the trench applies on and below a line 300mm above the outside top of the pipe. Above the 300mm line the trench backfill material shall be as described in Clause 505 of SHW.
5. The concrete bed or surround may extend to the sides of the trench or be of minimum width. Class B material is to be used to fill any voids so formed.
6. For Type Z trench the concrete cover may be formed to a radius batter or horizontal surface. Min. cover of concrete shall be 150.

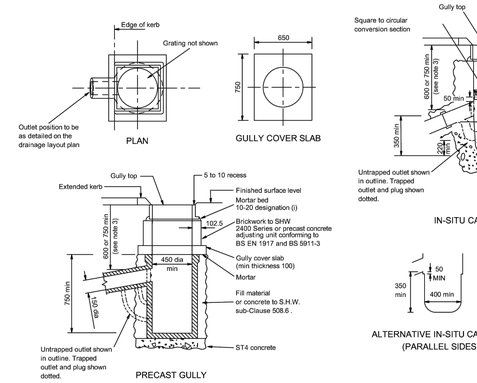


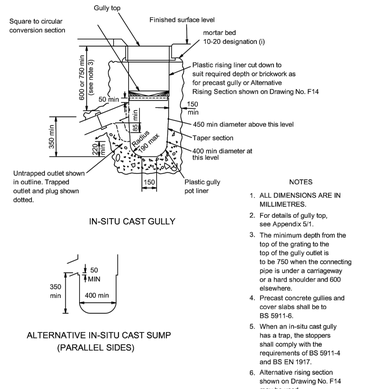
FILTER DRAINS - TRENCH & BEDDING DETAILS
(HCD DRAWING F1)



NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. Dimension X is the external diameter of the pipe.
3. This drawing is to be read in conjunction with Appendix 5/1
4. For details of section of the drain at surface level refer to the 'B' series of drawings.
5. Pipes shall comply with the requirements for filter drain pipes in Table 5/1 of the S.H.W.
6. Pipes are to be laid with slots or perforations upwards where a concrete bed is used. For other beds the slots shall be orientated as described in Appendix 5/1.
7. Minimum drain width Y = X+300 for drains not exceeding 1.5m cover below finished level. Y = X+450 for drains exceeding 1.5m cover below finished level.

FILTER DRAINS - TRENCH & BEDDING DETAILS
(HCD DRAWING F2)



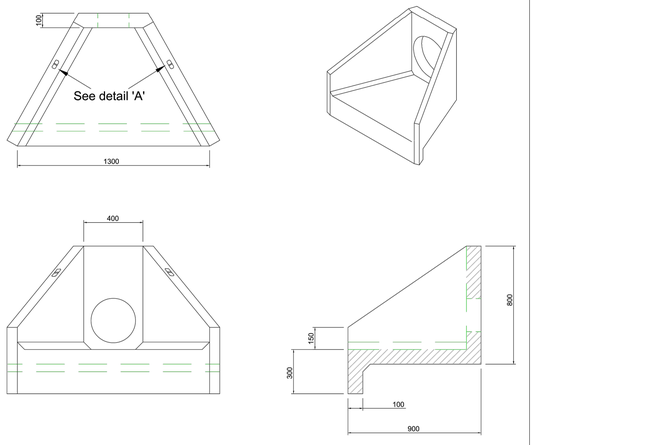


NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. For details of gully top, see Appendix 5/1.
3. The minimum depth from the top of the grating to the top of the gully outlet is to be 750 when the connecting pipe is under a carriageway or a hard shoulder and 600 elsewhere.
4. Precast concrete gullies and cover slabs shall be to BS 5911-6.
5. When an in-situ cast gully has a trap, the stoppers shall comply with the requirements of BS 5911-4 and BS EN 1917.
6. Alternative rising section shown on Drawing No. F14 may be used.
7. All ST concrete shall be to SHW, Clause 2602.

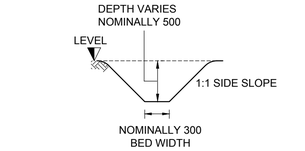
PRE-CAST GULLY
(HCD DRAWING F13)

H3C Specification Information

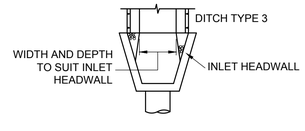
- Opening in back all cast to suit outside diameter of the pipework
- Invert level of pipe can be set to your specification
- H3C suitable for pipework up to 300mm ID twin wall or clay / 225mm ID concrete



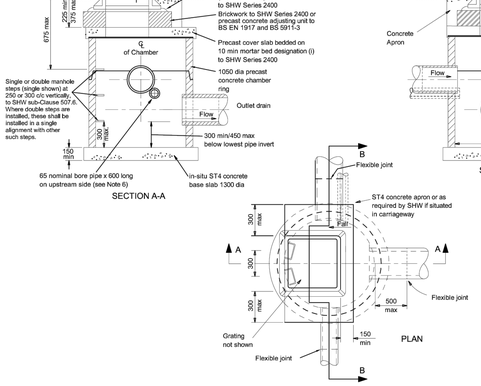
HEADWALL DETAILS
(ALTHON H3C HEADWALL)



UNLINED DITCH



CONNECTION TO INLET HEADWALL



TYPE 7 CHAMBER (1200mm CATCHPIT)
(HCD DRAWING F11)

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. Catchpit to be constructed in precast concrete to BS EN 1917 and BS 5911-3.
3. Invert details, number of branches and type of gully top are shown on the Drawings and Appendix 5/1.
4. Mortar to be designation (i) to SHW Series 2400.
5. Pipes to be built into the catchpit with designation (i) mortar are shown on the Drawings and Appendix 5/1.
6. Pipe to be built into catchpit to drain lower portion of trench. Pipe is to be placed above any concrete bed to filter drain.
7. The gully top is to be set as dimensioned below the adjacent:
   a) hard shoulder (for verges)
   b) hard strip (for dual 2 central reserve)
   c) finished level in other locations.
8. See SHW, sub-Clause 507.7 regarding backfilling/surround to chamber.
9. All ST concrete shall be to SHW, Clause 2602.

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. ONLY WRITTEN DIMENSIONS SHALL BE USED, DO NOT SCALE.
3. FILTER DRAIN TO BE USED THERMOPLASTIC WITH STRUCTURED WALL (MIN PIPE GROUP 11) AS PER HA 40/01 APPENDIX D, FIGURE E.
4. FILTER DRAIN BEDDING FILL MATERIAL AS PER HCD DRAWING F2.
5. CARRIER DRAIN TO BE USED NON-RIGID FLEXIBLE/THERMOPLASTIC PIPES OF MATERIAL STIFFNESS > 6 KPa AS PER HA 40/01 APPENDIX D FIGURE D. 2.
4. CARRIER DRAIN BEDDING FILL MATERIAL TYPE 'S' OR 'T' AS PER HCD DRAWING F1.
5. PROPOSED GULLY TO BE USED AS PER HCD DRAWING F13.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following:

CONSTRUCTION
N/A

MAINTENANCE/CLEANING
N/A

DECOMMISSIONING/DEMOLITION
N/A

It is assumed that all works will be carried out by a competent contractor working, where appropriate, to an approved method statement

Rev.	Date	Description	By	Chk'd	App'd
P1	23/02/2017	FIRST ISSUE	M.C.	A.A.	A.R.

Drawing Status: WORK IN PROGRESS
Suitability: S0

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Client

Project Title: A40 EAST OF REDSTONE CROSS NEAR NARBERTH

Drawing Title: STANDARD DETAIL

Scale	Designed	Drawn	Checked	Authorised
AS SHOWN	A.A.	M.C.	A.A.	A.R.
Original Size	Date	Date	Date	Date
A1	23/02/17	23/02/17	23/02/17	23/02/17

Drawing Number: AR03-004-ATK-HGN-SWTRA-DR-D-0004
Revision: P1

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DO NOT SCALE

Millimetres 0 10 100

EXTENT OF WORKS

CUTLINE

FOR CONTINUATION SEE BELOW

CUTLINE

FOR CONTINUATION SEE ABOVE

CUTLINE

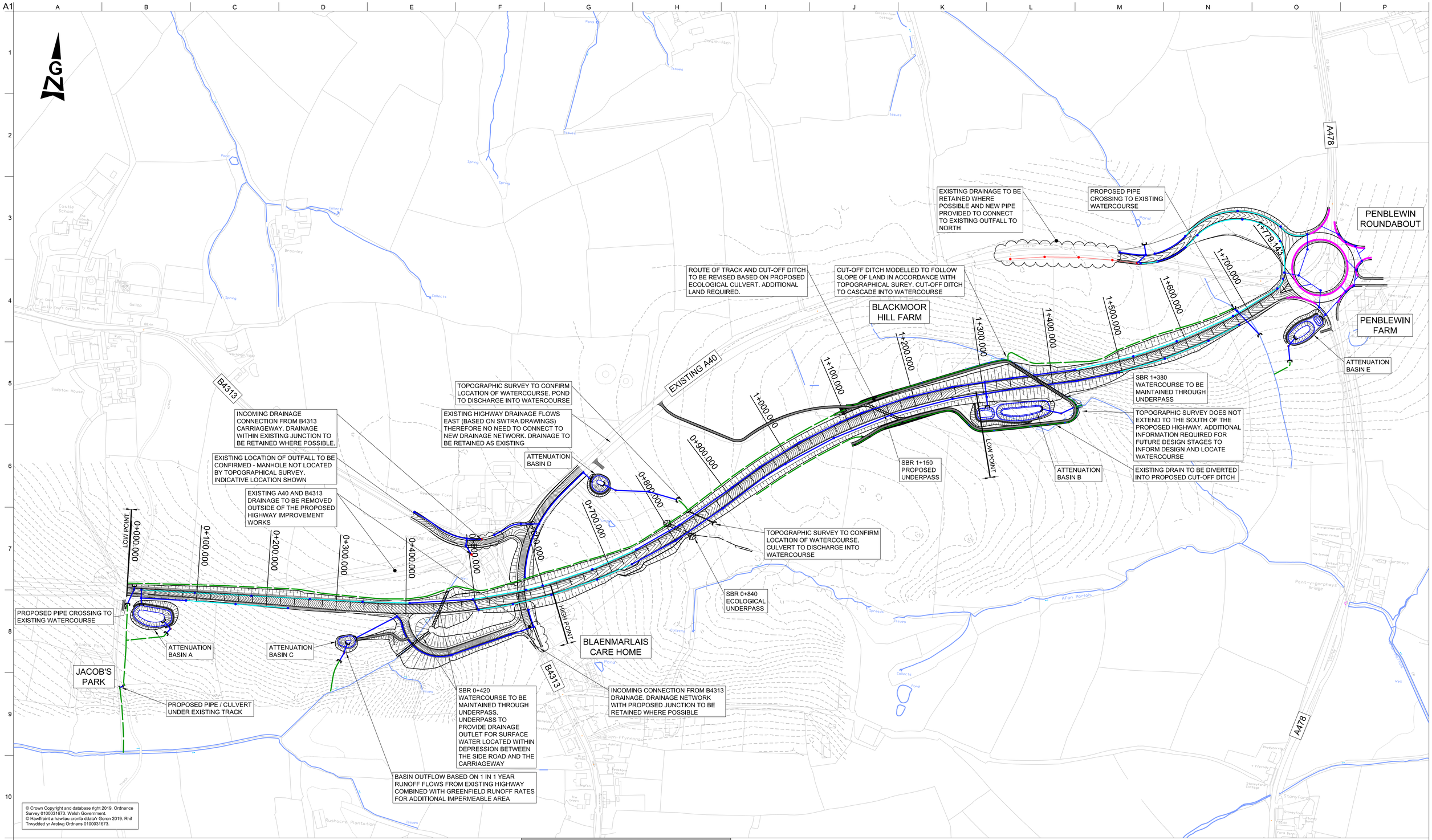
EXTENT OF WORKS

OH11kV OH11kV OH11kV

Appendix C

Drainage Drawings

C1 Drainage Drawings



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Legend

- Proposed Carrier pipe Type 21A, HCD B9
- Existing Carrier pipe
- Filter drain Type 1A, HCD B1
- Kerb Drainage
- Proposed Catchpit / Manhole
- Existing Catchpit/Manhole
- Cut off ditch
- Existing Culvert and Headwall
- Proposed Culvert and Headwall. See note 15
- Flow control device
- Headwall
- Proposed access to ponds
- Existing Watercourse

Notes

1. All dimensions in millimetres unless stated otherwise.
2. Condition of existing side road drainage assumed adequate, unless shown otherwise. Allow for minor improvement works to tie-ins.
3. Abandonment and/or alterations to existing drainage has not been considered
4. Gully locations are not shown with the exception of the roundabouts. Gullies required along the pavement edge where carrier pipes are present, approximately spaced at 12m.
5. Attenuation ponds to be unlined, unless in high ground water areas. Flow control device on outlet.
6. Earthworks for cut off ditches not shown.
7. Culverts for cut off ditches assumed to be 600mm dia.
8. Allow for headwalls at upstream and downstream of culverts. Upstream headwall to be blockstone with insitu concrete apron. Downstream headwall to be gabion baskets with concrete apron. Headwalls are required at pond inlets and outlets.
9. Allow for 15m regrading of watercourses at culverts.
10. Culvert sizes are estimates only. Actual culvert sizes to be provided in detailed design stage.
11. Attenuation ponds to be fenced with post and four rail fence with unbound access tracks around the perimeter.
12. Ordinary watercourse consents may be required for outfalls to watercourse and any proposed culverts.
13. Edge of carriageway fin drains not shown, but are required. To be in accordance with DMRB HCD F18.
14. All materials and details to be in accordance with the DMRB.
15. Access to all culverts to be obtained within the highway easement at the toe of the embankment.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
Flows of existing watercourses to be maintained during construction of culverts beneath highway.

Maintenance / Cleaning
Suitable access to be provided for safe maintenance of culverts beneath highway.

Use
Fencing to be provided around the attenuation basins in accordance with RoSPA guidelines.

Decommissioning / Demolition
Flows of existing watercourses to be maintained during demolition of culverts beneath highway.

Rev	Date	Description	By	Chkd	Appd	Auth
P01	27/11/19	PRELIMINARY ISSUE	JN	AR	TE	---
P02	16/03/20	READY FOR ISSUE	ES	GJ	TE	---
P03	18/03/20	PRELIMINARY ISSUE	JN	RC	RC	GD
P04	28/05/20	FOR ISSUE	CB	AR	TE	---

Project Title
A40 PENBLEWIN TO REDSTONE CROSS IMPROVEMENTS

Client
Llywodraeth Cymru
Welsh Government

Delivery Team
ARUP
MOTT MACDONALD
ARCADIS
RICHARDS

Drawing Title
HIGHWAY DRAINAGE

Suitability
S4 | SUITABLE FOR STAGE APPROVAL

Scale at A1 1:2500

Rev	By	Chkd	Appd	Auth
P04	CB	AR	TE	---
	Date 28/05/20	Date 28/05/20	Date 28/05/20	Date ---

Name
A40PRC - ARP - HDG - SWI - DR - D - 0001
Project | Originator | Volume | Location | Type | Role | Number

Appendix D

P2RC Hydrological Assessment

D1 P2RC Hydrological Assessment

Project	**A40 Penblewin to Redstone Cross Improvements**
Subject	P2RC Hydrological Assessment
File Reference	A40PRC-ARP-HDG-SWI-FN-D-0003
Prepared by	3
Status	**S3 | SUITABLE FOR REVIEW & COMMENT**
Revision | Date	P01 | 27/11/19

1 Introduction

1.1.1 This technical note details the hydrological assessment undertaken for a section of the A40, from Penblewin to Redstone Cross. As part of the proposed improvements, the drainage strategy will be required to attenuate flows from the scheme to the Greenfield Runoff Rate (GRR).

1.1.2 The hydrological assessment was undertaken to estimate the GRR along the proposed alignment, to allow attenuation ponds and culverts along the scheme to be appropriately sized. This dual purpose led to the recommendation of two different sets of peak flow values, based on winter rainfall profile for the runoff rates, and summer for culvert sizing (see section 4).

2 Study site

2.1.1 The study section of the proposed highway alignment from Penblewin to Redstone Cross spans over two catchments: a) an unnamed tributary of Afon Marlais and b) an unnamed tributary of Narberth Stream (Figure 1). For the purpose of this report, these will be referred to as Western Afon Marlais and Eastern Narberth Stream, as situated in relation to their respective, larger catchments.

2.1.2 Western Afon Marlais has two branches (Figure 1). The western branch intersects the proposed A40 highway in one place (western crossing) and the other branch in 2 places (middle crossing and eastern crossing). The Eastern Narberth Stream crosses underneath the proposed alignment in one place (Narbeth crossing).

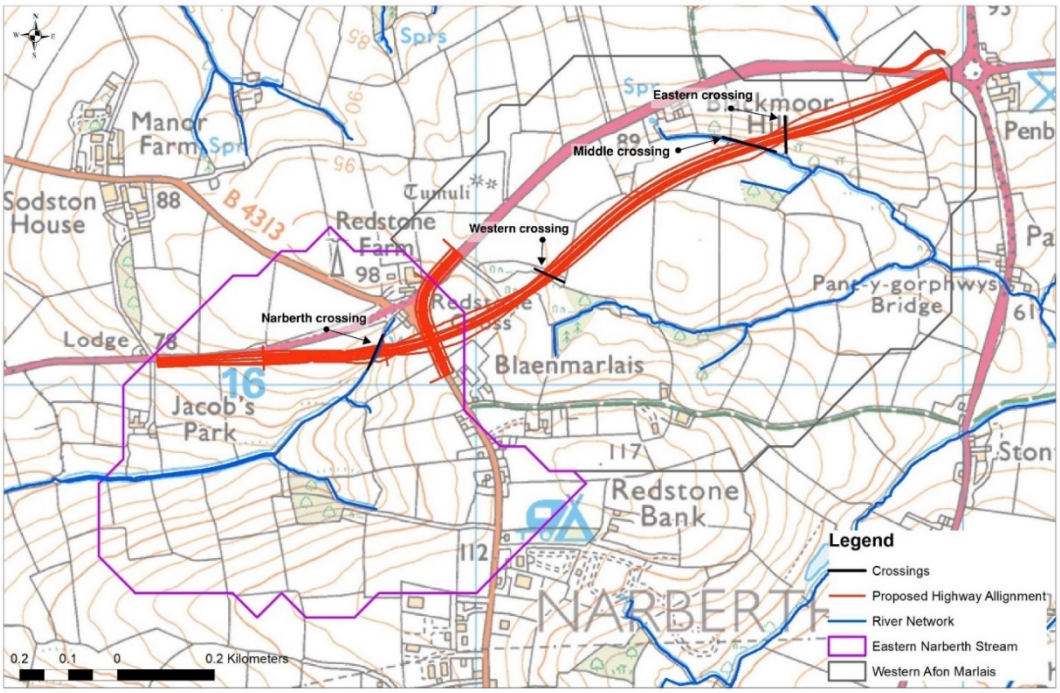

Figure 1. Catchments containing proposed highway alignment between Penblewin and Redstone Cross. The river crossing locations are also marked.

3 Hydrological assessment

3.1 Overview

3.1.1 To design the highway drainage system, the GRR for the 1, 5 and 100 year return period events were required for the study catchments. The QMED and 1 in 30 year event were included in the results for a more comprehensive comparison between the different methods used: a) IH 124, b) ReFH2 and c) FEH statistical method.

3.1.2 Catchment descriptors for Eastern Narberth Stream and Western Afon Marlais were obtained from the FEH Online Service. The catchment areas of the individual crossings are too small to appear on the FEH Web Service (catchments smaller than 0.5km2 are not recognised). The smallest catchment boundaries returned by the website are just above 0.5km2, presented in Figure 1, named herein as Eastern Narberth Stream and Western Afon Marlais. The calculations were based on the catchment descriptors of these latter catchments, scaling the values to the crossing locations where applicable. It is therefore assumed that the flows for the larger catchments are representative of the smaller sub-catchments at the crossings.

3.2 Catchment descriptors

3.2.1 The catchment boundaries for the Eastern Narberth Stream and Western Afon Marlais catchments were compared against the boundaries derived using Lidar data and OS mapping. The comparison showed that the difference of areas was less than 0.5% of the total catchment area; therefore, the FEH catchment boundaries were deemed appropriate and no adjustment was undertaken.

3.2.2 Table 1 presents the main FEH catchment characteristics for the two catchments.

Table 1. Main catchment characteristics for Eastern Narberth Stream and Western Afon Marlais, obtained from FEH Web Service.

Catchment Descriptor	Eastern Narberth Stream	Western Afon Marlais
Area (km^2)	0.5125	0.77
FARL	1	1
FPEXT	0.0049	0.0097
BFIHOST	0.583	0.578
SAAR (mm)	1298	1289
SPRHOST (%)	32.01	32.19
URBEXT2000	0.0024	0

3.2.3 The calculated flows can be downscaled based on the catchment of each crossing point underneath the A40 road. The estimated catchment areas for each crossing based on available LIDAR and OS mapping are presented below.

- Eastern Narberth Stream (NGR centroid: SN 10674 15875)
    - Narberth crossing catchment area: 0.085 km2 (16.6% of total catchment)
- Western Afon Marlais (NGR centroid: SN 11450 16270)
    - Western crossing catchment area: 0.021 km2 (2.8% of total catchment)

- Middle crossing catchment area: 0.222 km2 (28.9% of total catchment)
- Eastern crossing catchment area: 0.024 km2 (3.1% of total catchment)

3.3 Eastern Narberth Stream

3.3.1 IH 124 Method

3.3.1.1 The HR Wallingford online IH124 tool was used1. The default return periods produced by the IH 124 tool are 1 in 1 year, 1 in 30 year and 100 year. The tool assigns the catchment in the hydrological region number 9, based on its geographical location. The soil type was assigned manually a value of 0.2 based on the SPR value. The results of the IH 124 assessment are presented below in Table 2 and detailed in Appendix A.

Table 2. Peak flows calculated using IH 124 method for Eastern Narberth Stream catchment

Return Period	Peak flows (m^3/s)	Peak flows (l/s/ha)
1 year	0.163	3.18
Qbar	0.192	3.75
30 year	0.374	7.3
100 year	0.476	9.29

3.3.2 ReFH2

[1] https://www.uksuds.com/drainage-calculation-tools/greenfield-runoff-rate-estimation, visited on 15 August 2019

3.3.2.1 The FEH13 DDF rainfall dataset, provided by the FEH Web Service was used. Unlike IH124, ReFH2 offers the possibility to set event duration and season. The catchment is rural and the ReFH 2 Technical Report recommends using winter seasonality. However, since these calculations will also be used to size river crossings and mitigate flood risk, the more conservative summer profile results were preferred for the crossing design, with winter profile adopted for the GGR values.

3.3.2.2 Critical duration was calculated for the 100 year return period event. The peak flow was calculated for different event durations for summer and winter profiles, to determine the duration which provides the highest flow peak (3.7hr, summer profile). This duration was taken forward to calculate peak flows for the remaining return periods i.e. 1, 2, 5 and 30 year.

3.3.2.3 The 1, 2, 5, 30 and 100 year peak flow outputs for the Eastern Narberth Stream catchment are contained in Appendix B. The peak flows calculated by the ReFH 2 method and GRR estimates for summer and winter profiles are provided in Table 3.

Table 3. Peak flows calculated using ReFH2 for summer and winter profiles for Eastern Narberth Stream catchment (3.7h event duration).

Return Period	Summer profile		Winter profile	
	Peak flows (m^3/s)	GRR (l/s/ha)	Peak flows (m3/s)	GRR (l/s/ha)
1 year	0.29	5.62	0.24	4.64
QMED	0.32	6.3	0.27	5.17
5 year	0.44	8.5	0.35	6.9
30 year	0.65	12.71	0.52	10.15
100 year	0.83	16.13	0.66	12.79

3.3.3 FEH Statistical Assessment – Pooled Analysis

3.3.3.1 To undertake the FEH pooled analysis, the latest version of the HiFlows UK data set was used (version 7.0). Only stations that are deemed suitable for pooling were included. EA Science Report

090031 provides guidance and best practice on estimating peak flows and hydrographs for small catchments. The report recommends that on ungauged catchments, QMED data should be transferred from nearby, gauged catchments. The use of a geographically close catchment prevents introducing uncertainties from local flooding factors that may not be contained within catchment descriptors. The QMED adjustment factor in the data transfer equation is moderated based on distance between catchment centroids, so geographically close stations will have a larger influence.

3.3.3.2 A search on the NRFA website showed that there are five gauging stations within 21km of the site. In order of geographical distance, they are presented in Table 4.

3.3.3.3 All catchments are significantly larger than the subject site (>50 times). For all potential donor sites, a comparison of QMED was undertaken between that calculated using catchment descriptors and the measured values observed from annual maxima. This comparison is shown in Table 5 below.

Table 4. Potential donor sites for donor adjustment in WINFAP within 21 km of Eastern Narberth Stream catchment

Station number	Station name	Distance (km)	Area (km^2)	BFIHOST	FARL
61002	Eastern Cleddau at Canaston Bridge	9	181.87	0.537	0.967
60003	Taf at Clog-y-Fran	10.53	216.44	0.553	0.99
61003	Gwaun at Cilhedyn Bridge	19.08	28.77	0.494	1
61001	Western Cleddau at Prendergast Mill	19.12	197.83	0.56	0.996
60004	Dewi Fawr at Glasfryn Ford	20.96	36.8	0.569	1

Table 5. Comparison of observed versus calculated QMED for potential donor sites

Station	Oberved QMED (m^3/s)	Calculated QMED (m^3/s)	$QMED_{obs}/QMED_{cds}$
61002	80.581	69.254	1.164
60003	74.77	83.825	0.892
61003	21.706	20.642	1.052
61001	71.878	64.65	1.112
60004	18.091	18.525	0.977

3.3.3.4 Station 61002 was removed from the donor pool due to low value of FARL. Station 61003 was removed due to low BFIHOST value compared to target site (refer to Table 4).

3.3.3.5 The donor adjustment was applied to QMED using the remaining 3 donor stations, which led to an adjusted value of 0.385 m3/s from the calculated 0.39 m3/s from FEH catchment characteristics, so a minimal difference.

3.3.3.6 The default pooling group consisted of 15 stations with a total of 502 years of data. This default pooling group had a standardised test value (H2) of 2.0872, indicating that the pooling group was possibly heterogeneous and a review of the group was optional. A review of the pooling group was undertaken and the following station was removed:

- Station 47022 – Tory Brook at Newham Park due to low FARL value.

3.3.3.7 The resulting pooling group consisted of 14 stations with a total of 478 years of data. Two stations were added to achieve a minimum record of 500 years.

- Station 57017: Rhondda Fawr at Tynewydd
- Station 27010: Hodge Beck at Bransdale Weir

3.3.3.8 The modifications to the pooling group resulted in a H1 value of 2.1892. The modified pooling group remains possibly heterogeneous, but no obvious justifications are available to make further changes.

3.3.3.9 The modified pooling group was used to derive growth factors which were then multiplied with the value of QMED using donor adjustment to produce peak flow estimate for the 1, 5, 30 and 100 year return period events. These were then scaled by the catchment area to determine the GRR. The GL flood frequency curve was adopted as it provided the most reasonable estimates due to an acceptable Goodness of Fit (-0.9918). The stations included in the pooling group assessment are included in Appendix C.

Table 6. Peak flows calculated using WINFAP statistical method for Eastern Narberth Stream catchment.

Return Period	Peak flows (m^3/s)	Peak flows (l/s/ha)
1 year	0.08	1.56
QMED	0.385	7.51
5 year	0.508	9.91
30 year	0.767	14.96
100 year	0.998	19.47

3.4 Western Afon Marlais

3.4.1 IH 124 Method

3.4.1.1 The same methodology and tools as the previous catchment were used for this one. The catchment falls on region number 9, based on its geographical location. The soil type was assigned manually a value of 0.2 based on the SPR value. The results of the IH 124 assessment are presented below in Table 7 and detailed in Appendix A.

Table 7. Peak flows calculated using IH 124 method for Western Afon Marlais catchment

Return Period	Peak flows (m^3/s)	Peak flows (l/s/ha)
1 year	0.163	3.01
Qbar	0.192	3.55
30 year	0.374	6.92
100 year	0.476	8.79

3.4.2 ReFH 2

3.4.2.1 The ReFH 2 has been used in the same way described for the Eastern Narberth Stream catchment. The critical duration was estimated as 3.9hr (summer profile) and used to calculate peak flows for the remaining return periods i.e. 1, 2, 5 and 30 year return period.

3.4.2.2 The 1, 2, 5, 30 and 100 year peak flow outputs for the Western Afon Marlais catchment are contained in Appendix B. The peak flows calculated by the ReFH2 method and GRR estimates for summer and winter profiles are provided in Table 8.

Table 8. Peak flows calculated using ReFH 2 method for summer and winter profiles for Western Afon Marlais catchment.

Return Period	Summer profile		Winter profile	
	Peak flows (m3/s)	GRR (l/s/ha)	Peak flows (m3/s)	GRR (l/s/ha)
1 year	0.43	5.63	0.36	4.65
QMED	0.48	6.28	0.4	5.16
5 year	0.65	8.46	0.53	6.87
30 year	0.97	12.6	0.78	10.13
100 year	01.23	16.0	0.98	12.72

3.4.3 FEH Statistical Assessment – Pooled Analysis

3.4.3.1 A search on the NRFA website showed that there are five gauging stations within 20km of the site. In order of geographical distance, they are presented in Table 10.

3.4.3.2 Similar to Eastern Narberth Stream, stations 61002 and 61003 were removed from donor pool due to low BFIHOST and FARL value respectively.

3.4.3.3 The donor adjustment was applied to QMED using the remaining 3 donor stations which led to an adjusted value of 0.548m3/s from the calculated 0.556m3/s from FEH characteristics.

Table 9. Potential donor sites for donor adjustment in WINFAP within 20 km of Eastern Narberth Stream catchment.

Station number	Station name	Distance (km)	Area (km^2)	BFIHOST	FARL
61002	Eastern Cleddau at Canaston Bridge	8.81	181.87	0.537	0.967
60003	Taf at Clog-y-Fran	9.67	216.44	0.553	0.99
61003	Gwaun at Cilhedyn Bridge	18.99	28.77	0.494	1
61001	Western Cleddau at Prendergast Mill	19.55	197.83	0.56	0.996
60004	Dewi Fawr at Glasfryn Ford	20.09	36.8	0.569	1

3.4.3.4 The default pooling group consisted of 16 stations with a total of 509 years of data. This default pooling group had a standardised test value (H2) of 2.2741, indicating that the pooling group was possibly heterogeneous and a review of the group was optional. A review of the pooling group was undertaken and the following stations were removed:

- Station 47022 – Tory Brook at Newham Park due to low FARL value
- Station 49005 – Bolingey Stream at Bolingey Cocks Bridge due to short record (7 years of data)

3.4.3.5 The resulting pooling group consisted of 14 stations with a total of 478 years of data. Two stations were added to achieve a minimum record of 500 years.

- Station 57017: Rhondda Fawr at Tynewydd
- Station 27010: Hodge Beck at Bransdale Weir

3.4.3.6 The modifications to the pooling group resulted in a H1 value of 2.1667. The modified pooling group remains possibly heterogeneous, but no obvious justifications are available to make further changes.

3.4.3.7 The modified pooling group was used to derive growth factors which were then multiplied with the value of QMED using donor adjustment to produce peak flow estimate for the 1, 5, 30 and 100 year return period events. These were then divided by the catchment area to determine the GRR. The GL flood frequency curve was adopted as it provided the most reasonable estimates due to an acceptable Goodness of Fit (-0.9666). The stations included in the pooling group assessment are included in Appendix C.

Table 10. Peak flows calculated using WINFAP statistical method for Western Afon Marlais catchment.

Return Period	Peak flows (m^3/s)	Peak flows (l/s/ha)
1 year	0.115	1.49
QMED	0.548	7.12
5 year	0.723	9.39
30 year	1.092	14.18
100 year	1.420	18.45

4 Conclusions

4.1.1 A hydrological analysis was undertaken at the site of the proposed improvement to the A40 Penblewin to Redstone Cross. The proposed alignment spans over two catchments, the Eastern Narberth Stream and Western Afon Marlais. Three methods for estimating peak flows were used; IH 124, ReFH rainfall-runoff (v2) and the FEH statistical method. Results are presented in Table 11.

Table 11. Summary results for Eastern Narberth Stream and Western Afon Marlais

Catchment	Return Period	IH124 Peak Flows (l/s/h)	ReFH2		WINFAP Peak Flows (l/s/ha)
			Winter Peak Flows (l/s/ha)	Summer Peak Flows (l/s/ha)	
Eastern Narberth Stream	1 year	3.18	4.64	5.62	1.56
Western Afon Marlais		3.01	4.65	5.63	1.49
Eastern Narberth Stream	QMED	-	5.17	6.3	7.51
Western Afon Marlais		-	5.16	6.28	7.12
Eastern Narberth Stream	5 year	-	6.9	8.5	9.91
Western Afon Marlais		-	6.87	8.46	9.39
Eastern Narberth Stream	30 year	7.3	10.15	12.71	14.96
Western Afon Marlais		6.92	10.13	12.6	14.18
Eastern Narberth Stream	100 year	9.29	12.79	16.13	19.47
Western Afon Marlais		8.79	12.72	16.0	18.45

4.1.2 IH124 is a relatively coarse method based on regional growth curves, with no site-specific information. The surface area of the pooled catchments in the FEH Statistical method are much larger than the subject sites and very far away, which potentially makes the catchments too dissimilar to the subject sites. Furthermore, the pooling groups for the statistical method (both catchments) were noted

as heterogeneous before and after review, without an obvious justification to make further changes; this means that the sites selected for the pooling group are hydrologically heterogeneous.

4.1.3 However, ReFH2 is accepted for small catchments, down to plot-size, and it is based on site-specific catchment descriptors. It also has the benefit of allowing the representation of both summer and winter profiles which could be used to inform GRR and design values for river crossings. Therefore, its results are preferred.

4.1.4 Due to the dual purpose of the calculations, whereby green runoff rates and peak flood flows for culvert design are necessary, two sets of flow rates are proposed. ReFH2 winter outputs are proposed for GRR, whereas ReFH2 summer are proposed for culvert sizing, as they are more conservative and provide a more robust flood risk management approach. Given the similarity of the values between the two catchments, common values for both catchments and the full length of the A40 stretch considered are proposed (Table 12).

Table 12. Recommended GRR values.

Return period	GRR Winter (l/s/h)
QMED	5.17
1 in 5 year	6.9
1 in 30 year	10.15
1 in 100 year	12.79

4.1.5 For culvert design, the more conservative summer profile ReFH2 results are proposed. The peak river flows at the crossings, derived from the corresponding GRR and sub-catchment areas, are presented in Table 13 for summer profile.

Table 13. Peak flows (l/s) recommended for river crossings derived using ReFH2 (summer profile).

Return Period	Peak flows (l/s)			
	Narberth crossing	Western crossing	Middle crossing	Eastern crossing

QMED	53.50	13.5	140.2	14.9
5 year	72.18	18.2	189.1	20.1
30 year	107.92	27.2	282.8	30.0
100 year	136.98	34.9	362.9	38.5

Approvals

Revision	Status	Role	Name	Date
P01	**S3**	**Author**	Oana Standavid	07/11/19
		Checker	Miguel Piedra	6/11/19
		Approver	Tom Edwards	27/11/19
		Authoriser	Gary Davies	16/03/20

Appendix A: IH 124 Results

Eastern Narberth Stream

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Greenfield runoff estimation for sites

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Calculated by:	
Site name:	Eastern Narberth Stream
Site location:	SA67 7EY

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Site coordinates

Latitude:	
Longitude:	
Reference:	
Date:	2019-08-14 17:27

Methodology	IH124

Site characteristics

Total site area (ha)	51.25

Methodology

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type

	Default	Edited
SOIL type	0	2
HOST class	---	---
SPR/SPRHOST	0.00	0.3

Hydrological characteristics

	Default	Edited
SAAR (mm)	0	1298
Hydrological region	1	1
Growth curve factor: 1 year	-	0.85
Growth curve factor: 30 year	-	1.95
Growth curve factor: 100 year	-	2.48

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?
Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.
(2) Are flow rates < 5.0 l/s?
(3) Is SPR/SPRHOST ≤ 0.3?
Where groundwater levels are low enough the use of soakaways to avoid discharge offsite may be a requirement for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0	191.84
1 in 1 year (l/s)	NaN	163.06
1 in 30 years (l/s)	NaN	374.09
1 in 100 years (l/s)	NaN	475.76

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for use of this data in the design or operational characteristics of any drainage scheme.

Western Afon Marlais

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Greenfield runoff estimation for sites

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Calculated by:		Site coordinates	
Site name:	Western Afon Marlais	Latitude:	
Site location:	SA67 7EY	Longitude:	
		Reference:	
		Date:	2019-08-16 12:28

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Methodology	IH124

Site characteristics

Total site area (ha)	77

Methodology

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type

	Default	Edited
SOIL type	0	2
HOST class	---	---
SPR/SPRHOST	0.00	0.3

Hydrological characteristics

	Default	Edited
SAAR (mm)	0	1289
Hydrological region	1	1
Growth curve factor: 1 year	-	0.85
Growth curve factor: 30 year	-	1.95
Growth curve factor: 100 year	-	2.48

Notes:

(1) Is Q_{BAR} < 2.0 l/s/ha?

Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite may be a requirement for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	0	273.37
1 in 1 year (l/s)	NaN	232.36
1 in 30 years (l/s)	NaN	533.07
1 in 100 years (l/s)	NaN	677.96

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at http://uksuds.com/terms-and-conditions.htm. The outputs from this tool have been used to estimate storage volume requirements. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for use of this data in the design or operational characteristics of any drainage scheme.

Appendix B: ReFH 2

Eastern Narberth Stream

Winter profile				
Return period (yrs)	**Urbanised peak flow (m^3/s)**	**Urbanised direct runoff (ML)**	**As-rural peak flow (m^3/s)**	**As-rural direct runnof (ML)**
1	0.24	1.82	0.24	1.82
2	0.27	2.06	0.27	2.05
5	0.35	2.81	0.35	2.80
30	0.52	4.25	0.52	4.24
100	0.66	5.40	0.66	5.38
Summer profile				
Return period (yrs)	**Urbanised peak flow (m^3/s)**	**Urbanised direct runoff (ML)**	**As-rural peak flow (m^3/s)**	**As-rural direct runnof (ML)**
1	0.29	2.19	0.29	2.19
2	0.32	2.48	0.32	2.47
5	0.44	3.41	0.43	3.40
30	0.65	5.18	0.65	5.17
100	0.83	6.63	0.83	6.61

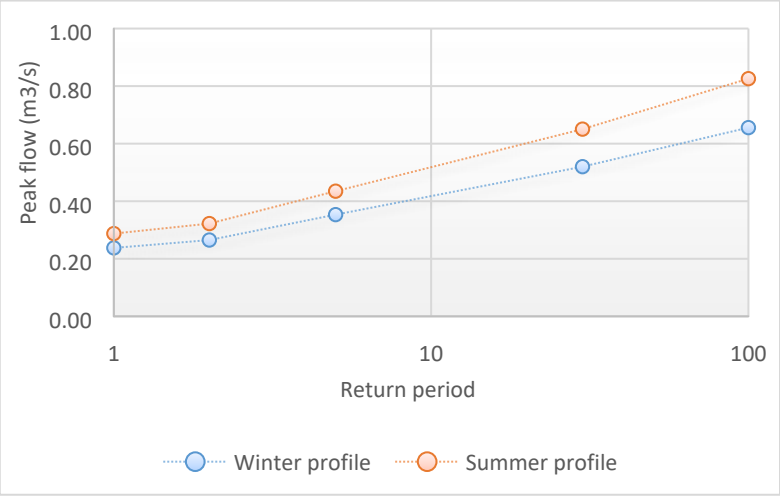

Figure B1. Peak flows for summer and winter profiles for Eastern Narberth Stream catchment

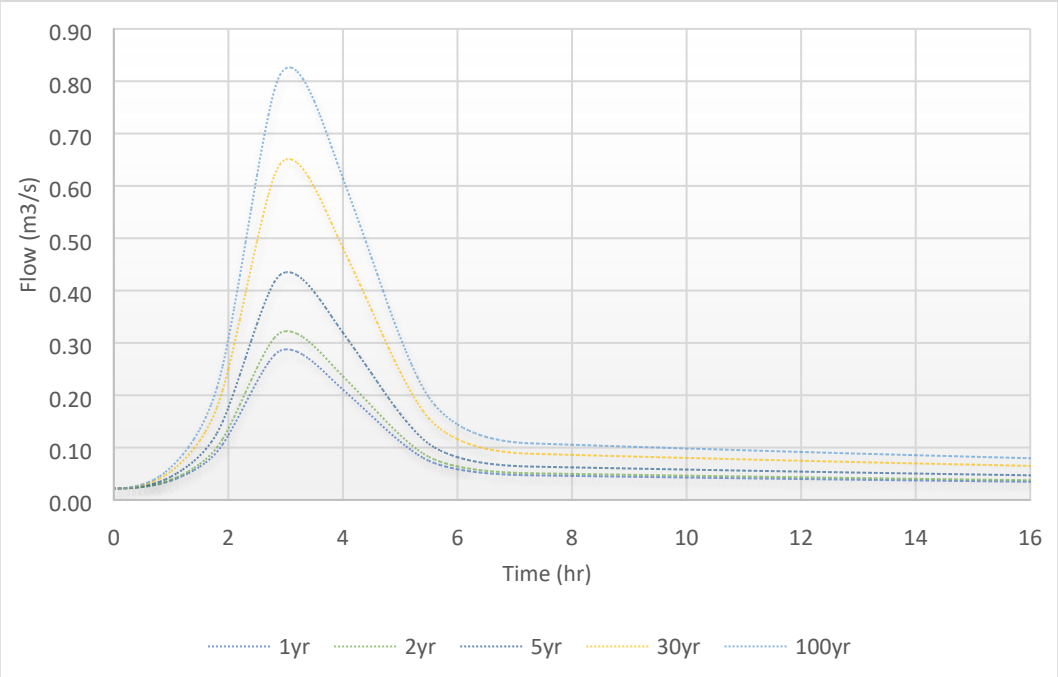

Figure B2. Summer profile hydrographs for different return periods for Eastern Narberth Stream catchment

Western Afon Marlais

Summer profile					
Return period (yrs)	**Urbanised peak flow (m^3/s)**	**Urbanised direct runoff (ML)**	**As-rural peak flow (m^3/s)**	**As-rural direct runnof (ML)**	
1	0.433	3.427	0.433	3.427	
2	0.483	3.852	0.483	3.852	
5	0.652	5.285	0.652	5.285	
30	0.970	8.030	0.970	8.030	
100	1.232	10.233	1.232	10.233	
Winter profile					
Return period (yrs)	**Urbanised peak flow (m^3/s)**	**Urbanised direct runoff (ML)**	**As-rural peak flow (m^3/s)**	**As-rural direct runnof (ML)**	
1	0.358	2.851	0.358	2.851	
2	0.397	3.201	0.397	3.201	
5	0.529	4.370	0.529	4.370	
30	0.780	6.586	0.780	6.586	
100	0.979	8.350	0.979	8.350	

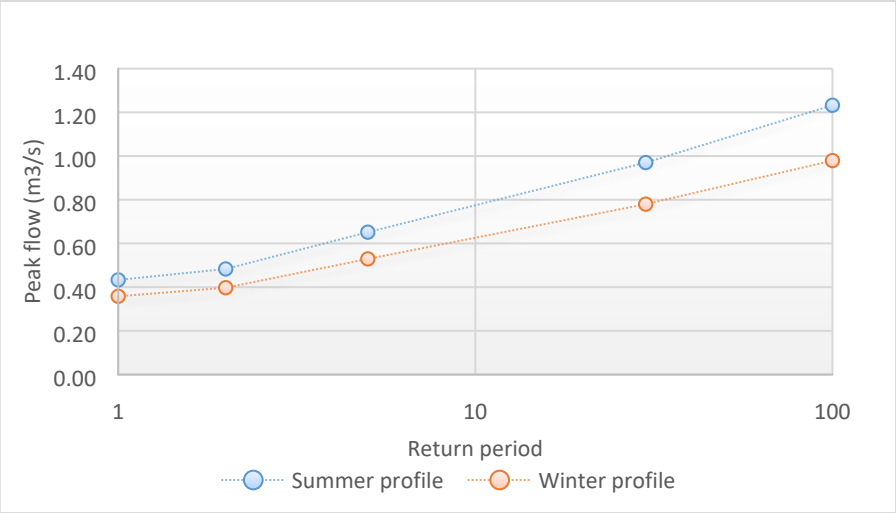

Figure B3. Peak flows for summer and winter profiles for Western Afon Marlais catchment

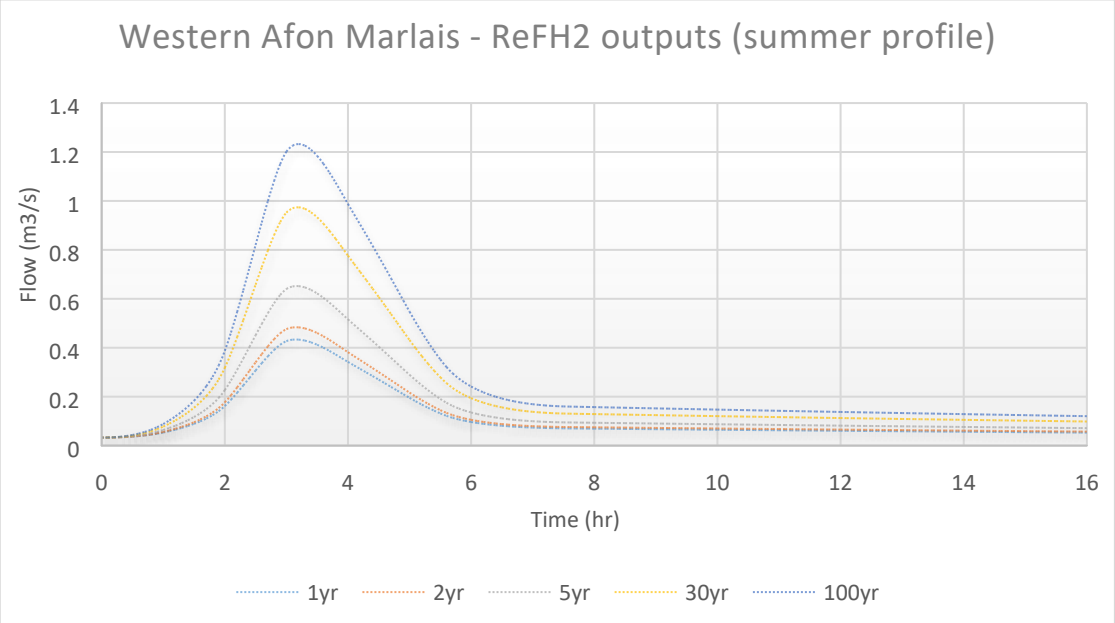

Figure B4. Summer profile hydrographs for different return periods for Western Afon Marlais catchment

Appendix C: WINFAP 4 statistical method results

Eastern Narberth Stream

Table C1. Initial pooling group (highlighted in red removed stations)

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.819	40	1.84	0.166	0.31	0.432
45816 (Haddeo @ Upton)	3.618	24	3.489	0.306	0.387	0.927
91802 (Allt Leachdach @ Intake)	3.787	34	6.35	0.153	0.257	0.74
28033 (Dove @ Hollinsclough)	3.827	38	4.225	0.234	0.405	0.439
27051 (Crimple @ Burn Bridge)	3.952	45	4.564	0.221	0.144	0.307
92002 (Allt Coire Nan Con @ Polloch)	4.06	16	FALSE	0.101	0.337	1.652
54022 (Severn @ Plynlimon Flume)	4.155	38	14.988	0.156	0.171	0.918
71003 (Croasdale Beck @ Croasdale Flume)	4.309	37	10.9	0.212	0.323	0.145
25003 (Trout Beck @ Moor House)	4.415	44	15.142	0.168	0.294	0.332
49006 (Camel @ Camelford)	4.47	11	11.154	0.124	-0.185	2.354
25011 (Langdon Beck @ Langdon)	4.503	28	15.878	0.238	0.318	1.072
47022 (Tory Brook @ Newnham Park)	4.586	24	6.651	0.265	0.138	0.868
206006 (Annalong @ Recorder)	4.700	48	15.33	0.189	0.052	2.203
27073 (Brompton Beck @ Snainton Ings)	4.779	36	0.816	0.203	0.06	0.752
25019 (Leven @ Easby)	4.807	39	5.677	0.34	0.377	1.859
Total		**502**				
Weighted means				**0.205**	**0.235**	

Table C2. Final pooling group (highlighted in green added stations)

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.825	40	1.84	0.166	0.31	0.469
45816 (Haddeo @ Upton)	3.625	24	3.489	0.306	0.387	1.013
91802 (Allt Leachdach @ Intake)	3.793	34	6.35	0.153	0.257	0.795
28033 (Dove @ Hollinsclough)	3.834	38	4.225	0.234	0.405	0.418
27051 (Crimple @ Burn Bridge)	3.959	45	4.564	0.221	0.144	0.465
92002 (Allt Coire Nan Con @ Polloch)	4.066	16	13.54	0.101	0.337	1.914
54022 (Severn @ Plynlimon Flume)	4.161	38	14.988	0.156	0.171	0.902
71003 (Croasdale Beck @ Croasdale Flume)	4.316	37	10.9	0.212	0.323	0.143
25003 (Trout Beck @ Moor House)	4.422	44	15.142	0.168	0.294	0.351
49006 (Camel @ Camelford)	4.477	11	11.154	0.124	-0.185	2
25011 (Langdon Beck @ Langdon)	4.509	28	15.878	0.238	0.318	1.323
206006 (Annalong @ Recorder)	4.707	48	15.33	0.189	0.052	2.115
27073 (Brompton Beck @ Snainton Ings)	4.785	36	0.816	0.203	0.06	0.947
25019 (Leven @ Easby)	4.813	39	5.677	0.34	0.377	2.004

57017 (Rhondda Fawr @ Tynewydd)	5.022	16	23.46	0.123	-0.076	1.044
27010 (Hodge Beck @ Bransdale Weir)	5.07	41	9.42	0.224	0.293	0.1
Total		**535**				
Weighted means				**0.203**	**0.224**	

Table C3. Results WINFAP pooling group assessment (rural flood frequency)**Error! Not a valid link.**Western Afon Marlais

Table C4. Initial pooling group (highlighted in red removed stations)

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.306	40	1.84	0.166	0.31	0.434
45816 (Haddeo @ Upton)	3.049	24	3.489	0.306	0.387	0.982
28033 (Dove @ Hollinsclough)	3.258	38	4.225	0.234	0.405	0.489
91802 (Allt Leachdach @ Intake)	3.264	34	6.35	0.153	0.257	0.634
27051 (Crimple @ Burn Bridge)	3.393	45	4.564	0.221	0.144	0.148
92002 (Allt Coire Nan Con @ Polloch)	3.53	16	13.54	0.101	0.337	1.695
54022 (Severn @ Plynlimon Flume)	3.62	38	14.988	0.156	0.171	0.627
71003 (Croasdale Beck @ Croasdale Flume)	3.75	37	10.9	0.212	0.323	0.177
25003 (Trout Beck @ Moor House)	3.855	44	15.142	0.168	0.294	0.364
49006 (Camel @ Camelford)	3.902	11	11.154	0.124	-0.185	2.464
25011 (Langdon Beck @ Langdon)	3.935	28	15.878	0.238	0.318	0.47
47022 (Tory Brook @ Newnham Park)	4.018	24	6.651	0.265	0.138	0.543
206006 (Annalong @ Recorder)	4.136	48	15.33	0.189	0.052	1.696
25019 (Leven @ Easby)	4.244	39	5.677	0.34	0.377	2
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	4.269	7	5.777	0.282	0.189	2.81
27073 (Brompton Beck @ Snainton Ings)	4.299	36	0.816	0.203	0.06	0.468
Total		**509**				
Weighted means				**0.208**	**0.233**	

Table C5. Final pooling group (highlighted in green added stations)

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
76011 (Coal Burn @ Coalburn)	1.306	40	1.84	0.166	0.31	0.469
45816 (Haddeo @ Upton)	3.049	24	3.489	0.306	0.387	1.013
28033 (Dove @ Hollinsclough)	3.258	38	4.225	0.234	0.405	0.418
91802 (Allt Leachdach @ Intake)	3.264	34	6.35	0.153	0.257	0.795
27051 (Crimple @ Burn Bridge)	3.393	45	4.564	0.221	0.144	0.465
92002 (Allt Coire Nan Con @ Polloch)	3.53	16	13.54	0.101	0.337	1.914
54022 (Severn @ Plynlimon Flume)	3.62	38	14.988	0.156	0.171	0.902
71003 (Croasdale Beck @ Croasdale Flume)	3.75	37	10.9	0.212	0.323	0.143
25003 (Trout Beck @ Moor House)	3.855	44	15.142	0.168	0.294	0.351
49006 (Camel @ Camelford)	3.902	11	11.154	0.124	-0.185	2
25011 (Langdon Beck @ Langdon)	3.935	28	15.878	0.238	0.318	1.323
206006 (Annalong @ Recorder)	4.136	48	15.33	0.189	0.052	2.115
25019 (Leven @ Easby)	4.244	39	5.677	0.34	0.377	2.004
27073 (Brompton Beck @ Snainton Ings)	4.299	36	0.816	0.203	0.06	0.947
57017 (Rhondda Fawr @ Tynewydd)	4.469	16	23.46	0.123	-0.076	1.044
27010 (Hodge Beck @ Bransdale Weir)	4.496	41	9.42	0.224	0.293	0.1
Total		**535**				
Weighted means				**0.198**	**0.229**	

Table C6. Results WINFAP pooling group assessment (rural flood frequency)

	RURAL					
Return Period	**GL Flood Growth Curve Factors**	**Factored Flows (m^3/s)**	**GEV Flood Growth Factors**	**Factored Flows (m^3/s)**	**PIII Flood Growth Factors**	**Factored Flows (m^3/s)**
1	0.209	0.115	0.274	0.150	0.505	0.277
2	1.000	0.548	1.000	0.548	1.000	0.548
5	1.319	0.723	1.349	0.739	1.377	0.755
30	1.992	1.092	2.015	1.104	2.014	1.104
100	2.592	1.420	2.508	1.374	2.414	1.323

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Welsh Government

A40 Penblewin to Redstone Cross Improvements

ES Appendix 7.4 Groundwater Flow and Level Assessment

A40PRC-ARP-EWE-SWI-RP-C-0001

P01 | S3

07/02/20

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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1 Introduction

1.1.1 In accordance with Appendix A of LA 113 the scheme has been reviewed in the context of potential impact to groundwater levels and flow, through the development of a conceptual site model and subsequent identification of all potential features which are susceptible to groundwater level and flow impacts.

2 Overview of Hydrological and Hydrogeological Setting

2.1 Surface Water

2.1.1 The following surface water features have been identified within the study area, presented on Volume 2, Figure 7.1:

a) There are multiple **unnamed tributaries of Longford Brook** to the north of the A40. The Longford Brook catchment is to the north of the ridgeline.

b) Unnamed tributaries of the **Afon Marlais** are largely located to the south of the existing A40 and the proposed alignment. From site visit observations, some of these tributaries could be classed as surface water drains. The Afon Marlais catchment forms the southern side of the ridgeline, with the majority of the scheme being in this area. As set out in Chapter 7, the Afon Marlais main river starts at the A478, 550m to the south east of the crossing point.

c) Unnamed tributaries of **Narbeth Brook**. The Narberth Brook catchment lies to the west of the Afon Marlais catchment. The western edge of the scheme from chainage 0+600 is within this catchment. Narberth Brook itself and the associated Cleddau Rivers SAC and SSSI designations are located 1.5km downstream from the scheme. Watercourses are shown on OS mapping in Volume 2, Figure 7.1 to rise 20m south of the existing A40 at Redstone Farm and would be crossed by the scheme. These are considered as ephemeral streams which would flow during wetter periods.

d) **Seven ponds** are within 500m of the scheme (Volume 3, Figure 7.1). All of the ponds appear to have no connection to the wider surface water drainage network. Therefore, impacts on these features would only occur as a result of changes in groundwater level.

e) **Springs** at multiple locations. As the proposed route follows the watershed between multiple catchments, the watercourses described above start within the study area, with the majority shown on OS mapping as being spring-fed.

2.2 Local hydrogeology

2.2.1 The review of published geology indicates that the scheme is underlain by four types of bedrock strata comprising, from west to east; sandstones of the Haverford Beds (0+000 to approx. 0+340), mudstones of the Slade and Redhill Formation (approx. 0+340 to 0+780), and the mudstones of the Dicrograptus and Llandelio flags (0+780 to 1+320). The Slade and Redhill beds also extend from 1+320 to the Penblewin Roundabout in the east of the scheme. Refer to Volume 2, Figure 7.5.

2.2.2 Hydrogeological map for South Wales indicates the scheme to be underlain by impermeable formations of mudstones, siltstones and thin, fine-grained sandstones. NRW classifies bedrock as secondary (A and B) aquifers. Glacial till is present from approximately 0+800 to 1+300, this superficial stratum; which is absent outside of this chainage length, is classed as unproductive strata. The study area includes three WFD surface water bodies and two WFD groundwater bodies, as detailed in Chapter 7 and shown on Volume 2, Figure 7.3.

2.2.3 The proposed alignment is shown to cross over two faults: the most easterly bisecting the alignment at approximately 80 degrees and the most westerly at around 45 degrees. The dip of the underlying bedrock is shown to vary considerably in both direction and dip angle which suggests the underlying bedrock is folded as well as faulted across the site. A third fault is shown to be present approximately 50m south of the proposed alignment and runs in an east-west direction.

2.2.4 A valley feature has been observed approximately at Ch. 1+400, this is between the Dicranograptus Beds Formation and Slade and Redhill Formation. In addition to this, a possible outcrop of the Mydrim Shales was noted which seemed to be steeply dipping, this suggests that the boundary between the formations could be faulted forming a weak zone picked out by the erosion and has led to the present-day watercourse in this location (Afon Marlais tributary feature ID11 on Figure 7.1).

2.2.5 Upon consideration of the above, it is clear that the faulted and folded bedrock strata and the boundaries between bedrock formations

influence groundwater level and subsequent groundwater features at surface. Given superficial strata are generally absent along the alignment (with the exception of glacial till), hydraulic gradient and depth to the groundwater table is influenced by existing topography.

2.2.6 Groundwater flows is anticipated to largely occur within the upper sections of the bedrock, within weathered and fractured zones, emerging at surface as springs where possible through fractures and fissures in bedrock or at change of bedrock properties/geological boundaries. Locally groundwater flow will be towards streams, which create low points in the local topography. Some springs correlate with the change in geology or the presence of faults. Refer to Volume 2, Figure 7.5. Faults may act as preferential flow paths or as barriers but generally would comprise a hydraulic barrier for groundwater flow.

2.3 Groundwater dependent features

2.3.1 Review of baseline conditions identified several groundwater features within 500m of the proposed scheme that are reliant on groundwater (such as the well and springs) and also features reliant on both groundwater recharge and surface water drainage. All features identified are detailed in the table below. The locations are shown on Volume 2, Figure 7.1.

2.3.2 Surface water features such as ponds and tributaries are expected to be fed by a mix of groundwater, precipitation and surface water run-off influenced by existing topography. The identified ponds are identified to be potentially indicative of former quarrying or extraction works, the relict depressions filling with water, and potentially supplied and/or recharged by shallow groundwater flow.

Table 1 Identified surface water and groundwater features within 500m of the alignment corridor (refer to Figure 7.5)

ID	Feature type	Ch.	Approximate distance from proposed main alignment	Approximate ground elevation mOD	Base flow	Surface water catchment
GW1	Spring	0+100	413m N	85	GW	Headwaters of unnamed tributaries of Longford Brook
GW2	Collects	0+420	450m N	90	GW/ SW run-off	
GW3		0+280	550m N	78		
GW4	Springs	0+500	490m N	85	GW	
GW5	Issues	0+700	550m N	85	GW	
GW6	Issues	1+150	375m N	86	GW	
GW7	Headwaters of unnamed tributary of Longford Brook;	1+590	130m N	93	GW/ SW run-off	
GW8	Spring	1+150	120m N	87	GW	Headwaters of unnamed tributaries of Afon Marlais
GW9	Collects	0+780	130m S	90	GW/ SW run-off	
GW10	Collects	1+100	350m S	90		
GW11	Issues	1+100	300m S	82	GW	
GW12	Issues	0+420	35m S	87	GW	Headwaters of unnamed tributaries of Narbeth Brook
GW13	Issues	0+420	320m S	87	GW	
GW14	Headwaters of unnamed tributary of Narberth Brook	0+480	40m N	96	GW/ SW run-off	
GW15	Well	0+480	40m N	96	GW	
GW16	GWDTE Woodland habitat (W6)	1+400	online	70-75	GW	
A	Pond	1+779	75m SE	86	GW	
B	Pond	1+779	450m N	75	GW	
C & D	Ponds	1+100	400m S	90	GW	
E	Pond	0+680	113m S	101	GW	
F	Pond	0+570	188m S	104	GW	
G	Pond - Flooded quarry	0+100	338m N	93	GW	

2.4 Groundwater Conditions

2.4.1 During the most recent 2019 ground investigation, groundwater strikes were generally recorded at depths of between the following:

a) 4mbgl to 11.5mbgl (96.06mOD to 80.34mOD) within the Slade and Redhill Formation;

b) 2.5mbgl and 11.5mbgl (75.6mOD to 74.99mOD) in the Dicrograptus Beds and;

c) Approximately 10.5mbgl (78.38mOD) in the Llandeilo Flags formation.

2.4.2 No groundwater strikes were recorded during the excavation of boreholes or trial pits in the Haverford Beds in the west of the scheme alignment.

2.4.3 Generally, the 2019 exploratory locations encountered the main groundwater body within the bedrock strata. However, in one instance, two strikes were recorded in strata of the Slade and Redhill formation; potentially associated with shallower weathered layers above impermeable bedrock.

2.4.4 More frequently, two strikes were recorded in exploratory hole locations where glacial till is present, with shallow strikes recorded at the base of or within the till itself and a deeper groundwater body within the bedrock strata which in these incidences, comprises the Dicrograptus beds. Groundwater was struck within the glacial till deposits at depths of generally 4mbgl (83 to 85mOD).

2.4.5 The 2019 ground investigation comprised three rounds of groundwater monitoring (November to December 2019) from installed standpipes. Monitored groundwater levels together with standpipe installation details are presented below, as illustrated on Figure 1:

Table 2 Standpipe installations and monitored levels

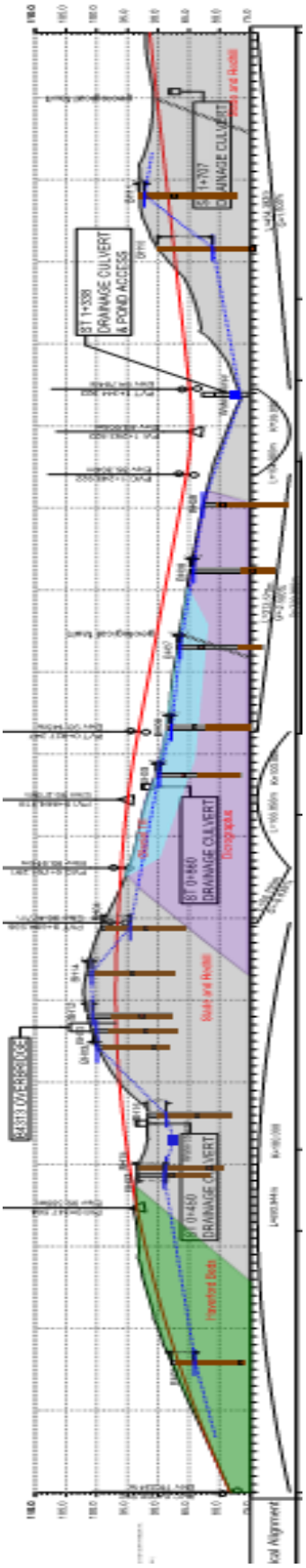
Exploratory hole	Installation depth (mbgl)	Monitored strata	Monitored strata description	Range of water levels (mbgl)	Range of water levels (mOD)
RCE-BH01	9 to 10	Haverford Beds Bedrock	Strong light grey/light brown fractured Sandstone.	3.87 to 4.12	84.08-83.85
RCE-BH02	9.5 to 10.5	Slade and Redhill Bedrock	Very poor recovery; Weak dark grey Mudstone/Siltstone; recovered as subrounded fine to coarse gravel.	4.41-4.66	89.02-88.94
RCE-BH15	6 to 7.5		Weak to very weak brown and grey Mudstone (heavily fractured). Generally recovered as nonintact with small bands of intact rock.	4.59- 5.11	88.96-88.44
RCE-BH16	7.5 to 9.5		Weak becoming medium strong dark grey occasionally thinly laminated Mudstone.	2.61-3.41	89.23-88.43
RCE-BH03	8 to 10		Very weak occasionally thinly laminated grey and dark grey Mudstone	0.02-0.19	100.04-99.87
RCE-BH13	8 to 9.5		Weak and medium strong dark grey Siltstone.	0.34-1.21	101.56-100.69
RCE-BH12	7 to 8.5		Weak dark grey occasionally brown Mudstone with thin grey laminations.	0.92-1.72	102.39-101.59
RCE-BH14	7 to 8.5		Moderately weak grey Mudstone.	0.82-1.69	102.84-101.97
RCE-BH04	6 to 7.5		Weak dark grey Mudstone locally grading to a Siltstone. Some laminations and lenses of light brown mudstone seen.	4.61-4.7	96-95.91
RCE-BH05	3.5 to 4.5	GLACIAL TILL	Firm becoming very stiff light brown slightly sandy slight gravelly Clay with low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse. Cobbles are subangular to subrounded of sandstone.	0.62 to 0.76	89.12-88.98
RCE-BH06	4.5 to 5.5		Dense pale brown clayey slightly sandy Gravel. Gravel is angular to sub angular fine to coarse mudstone	0.45-0.86	88.43-88.02
RCE-BH07	4 to 5		Stiff and very stiff pale brown slightly sandy slightly gravelly Clay with low	0.54-0.62	85.95-85.87

Exploratory hole	Installation depth (mbgl)	Monitored strata	Monitored strata description	Range of water levels (mbgl)	Range of water levels (mOD)
			cobble and boulder content of mudstone.		
RCE-BH08	9 to 10.5	Dicrograptus Bedrock	Very weak black/dark grey Mudstone (Heavily fractured)	0.47-0.63	79.92-79.76
RCE-BH09	2.2 to 3.2		Weak and moderately weak very dark grey Mudstone/ Siltstone.	0	78.1
RCE-BH10	14 to 16	Slade and Redhill Bedrock	Moderately weak brown and light grey and dark grey thinly (50mm) bedded Siltstone.	9.1-9.55	81.86 – 81.41
RCE-BH11	5 to 6.5		Moderately strong dark grey Siltstone.	0.94- 1.63	92.35-91.66

2.4.6 The results of the monitoring show that although groundwater strikes were largely recorded at depths greater than 5mbgl during the ground investigation, monitored groundwater levels suggest a much shallower groundwater body along the scheme. The 2019 ground investigation was undertaken in September, and therefore it has been undertaken following dryer summer months with respect to precipitation, which may be attributable to the lower groundwater levels than those monitored during the autumn/winter months.

2.4.7 The presence of a shallow groundwater table in the study area is confirmed by the presence of springs and issues. Generally, surface water features in the locale of the alignment can be correlated with monitored levels.

2.4.8 There is little difference between monitored levels in both glacial till (85.95-89.12mOD) and bedrock standpipes (where present) indicating hydraulic continuity, and in this section of the alignment – where glacial till is present and underlain by either the Dicrograptus beds and (in one location) Llandelio Flags, monitored groundwater is particularly shallow, with the 2019 RCEBH09 standpipe recording groundwater at surface level.


BT 1+339
DRAINAGE CULVERT
& POND ACCESS
BT 1+707
DRAINAGE CULVERT
BT 0+860
DRAINAGE CULVERT
Mudstone
Siltstone
Mudstone and Argillaceous Limestone
Interbedded Beds
Mudstone and Argillaceous Limestone
Mudstone
Siltst

3 Proposed Earthworks

3.1.1 To facilitate the proposed scheme, three cuttings (as shown on Figure 1 above) are proposed. Review of the findings of the 2019 ground investigation indicate that all cuttings will be undertaken within bedrock strata. Groundwater strike and monitoring data obtained during the 2019 ground investigation and the presence of numerous surface water (and groundwater) features within the study area indicate that the proposed works have a potential to impact groundwater flows and levels, and in turn, groundwater dependent features.

3.1.2 Cuttings can be summarised as follows:

a) Cutting 1 from 0+000 to 0+350 requiring up to 1.5m of excavation to achieve construction depths of approximately 85mOD to 94mOD;

b) Cutting 2 from 0+500 to 0+740 requiring 5m of excavation to achieve a construction depth of some 97mOD and;

c) Cutting 3 from 1+490 to 1+780 requiring 4.5m of excavation to achieve construction depths of 86mOD to 90.5mOD.

3.2 Cutting 1 Impact on Groundwater / Level Flow

3.2.1 The 2019 ground investigation undertaken within Cutting 1, shows ground conditions to comprise clayey gravel with low cobble content underlain by strong fractured sandstone from 1mbgl to at least 10mbgl (unproven), expected to be the Cethings Sandstone of the Haverford Beds Formation. The bedrock dip is expected southwards, however no dip angle is shown on the County Series Geological map.

3.2.2 Cutting 1 requires excavations up to 1.5m deep to achieve construction depths of approximately 85mOD to 94mOD. The 2019 ground investigation did not encounter any groundwater strikes in Cutting 1, within the Haverford Beds. However, groundwater has been monitored at levels of between 83.85mOD to 84.08mOD within this stratum. The proposed cutting depth is above the monitored level of groundwater and therefore from initial review, groundwater level is not anticipated to be impacted with respect to the proposed cutting.

3.2.3 There may be some minor seepages after a rainfall event through fractures into the proposed cutting, however impact on groundwater levels is not anticipated from the proposed cutting.

3.2.4 Although a number of surface water and groundwater features have been identified within 500m of the cutting, the proposed works are not anticipated to impact groundwater levels and therefore these features are not expected to be impacted.

3.3 Cutting 2 Impact on Groundwater / Level Flow

3.3.1 Published geology shows this portion of the alignment to overly the Slade and Redhill Mudstone Formation. There is potential for the Mydrim Shales Formation to be encountered at the eastern extent along with superficial deposits of Glacial Till. Dip angles are shown to be 22 to 30 degrees towards the west. RCE-BH12 and BH13 are located at the proposed abutments for a new overbridge over this cutting.

3.3.2 Construction of Cutting 2 requires excavations of up to 5m in depth to achieve construction depths of approximately 96mOD. All 2019 exploratory holes in this earthworks zone encountered clayey gravel to a maximum depth of 2.7mbgl. Underlying this was highly fractured very weak mudstone with bands of clayey gravel.

3.3.3 The 2019 trial pits excavated within the cutting area were terminated at approximately 2.1mbgl to 3.15mbgl due to difficultly progressing or collapsing, TP05, TP06 and TP18 encountered hard rock towards the bottom of the pits. All of the encountered strata are thought to be the Slade and Redhill Mudstone Formation.

3.3.4 Various strikes were recorded in the Slade and Redhill Formation during the ground investigation works. Strikes were generally recorded between 7.2mbgl (93.41mOD) and 11.5mbgl (88.56mOD), however shallower strikes have been recorded at 1.6mbgl (94.52mOD) and 4mbgl (96.06mOD). This indicates that in some instances, strikes have been recorded relatively close to the cutting depth.

3.3.5 Groundwater monitoring ranges have been recorded between 95.97mOD and 102.84mOD, generally being recorded around 100mOD. The proposed cutting depth is therefore below the monitored level of groundwater. Consequently, dewatering is likely to be required in this area of the scheme. The highway drainage will be installed to maintain the reduced groundwater level. This may impact groundwater level and flows within the vicinity of the cutting.

3.3.6 The baseline conditions review identified a number of groundwater

features, tributaries, streams and drainage features within 500m of the proposed Cutting 2, as detailed below. The features are shown on Volume 2, Figure 7.5.

Table 3 Features identified within 500m of the proposed Cutting 2 (0+500 to 0+740) at 96mOD.

ID	Feature type	Chainage	Approximate distance to Cutting 2	Approximate ground elevation, mOD	Potential for impact
GW2	Collects	0+420	450m N	90	No
GW8	Spring	1+150	470m NE	87	No
GW9	Collects	0+780	130m SE	90	No
GW10	Collects	1+100	420m SE	90	No
GW11	Issues	1+100	400m SE	82	No
GW12	Issues	0+420	100m SW	87	No
GW13	Issues	0+420	320m S	87	No
GW14	Headwaters of unnamed tributary of Narberth Brook	0+480	40m N	96	Yes
GW15	Well	0+480	40m N	96	No
C & D	Ponds	1+100	430m SE	90	No
E	Pond	0+680	130m S	101	Yes
F	Pond	0+570	250m S	104	No

3.3.7 Features GW2, GW8-13 and Ponds C and D are all located at lower elevation than the construction depth (96mOD) and therefore any dewatering activities or drainage are unlikely to impact the groundwater regime within which these features lie.

3.3.8 The headwaters of unnamed tributary of Narberth Brook (GW14), which is at 96mOD, the western reaches of the cutting may slightly impact groundwater levels, potentially reducing flow. However, this feature is likely to also receive surface water run-off, and therefore the overall impact is unlikely to be significant.

3.3.9 The construction details (i.e. depth of a response zone, abstracted bedrock formation) of the well (GW15) are unknown. However, considering that its response zone is likely to be at depth, it is likely to be below the proposed cut level, and therefore it is unlikely that the cutting would have a detrimental impact on yield if the well.

3.3.10 Pond F exists at 104mOD and is therefore located above the elevation of proposed construction depth. Pond F does not lie within the Slade and Redhill formation, rather sits within the Portfield and Haverford Mudstone formation. A geological fault separates these two formations, acting as a potential hydraulic barrier. Considering this, and the distance of this feature from the cutting (approximately 250m), it is considered unlikely the proposed cutting will impact this pond.

3.3.11 Pond E lies within the Slade and Redhill Formation at 101mOD and has, from desk study review, been identified as "potentially infilled land / pond", coinciding with a fault line. The pond lies some 130m south of the proposed cutting. The proposed cutting may have a slight impact on the pond recharge.

3.4 Cutting 3 Impact on Groundwater / Level Flow

3.4.1 Published geology shows the Cutting 3 portion of the alignment to overly the Slade and Redhill Mudstone Formation. No superficial deposits are recorded in this area. Dip angles are shown to be 15 degrees towards the north. A fault is recorded in a north-west to south-east direction at approximately Ch. 1+700.

3.4.2 Trial pits excavated within the cutting area as part of the 2019 ground investigation (TP14 and TP15) encountered gravel of mudstone from surface. This is thought to be highly fractured Slade and Redhill Mudstone Formation and is consistent with material encountered in the western extent of the scheme (in the locale of Cutting 2). The 2019 BH10 and BH11 also encountered the moderately weak to weak fractured mudstones to approximately 4mbgl, underlain by weak mudstone with occasional gravel banding. This stratum was encountered to depth on both holes (16m), this is thought to be the Slade and Redhill Formation.

3.4.3 In order to achieve construction depth Cutting 3 will be a maximum of 4.5mbgl, at some 87mOD at its lowest point in the west of the cutting area, increasing to 91mOD in the east. At present, the alignment in this area lies along a valley ridge, with topography dipping to the south and south east, and northwards towards the existing A40 highway. The valley of the unnamed tributary of Afon Marlais (feature ID11, Volume 2, Figure 7.1) forms a natural hydraulic barrier to the west of cutting.

3.4.4 No groundwater was encountered during drilling of the 2019 BH10,

whilst BH11 encountered a strike at 6mbgl (87.29mOD), the proposed cut depth in the location of BH11 is approximately 88mOD. Seepages were also recorded at 2.5mbgl and 1.7mbgl within TP14 and TP15 respectively.

3.4.5 Monitored groundwater levels range from 81.41mOD (BH10) to 92.35mOD (BH11) and therefore near the central and eastern extent of the cutting (in the locale of BH11) the groundwater table is above the construction depth. Consequently, dewatering is likely to be required in this area of the scheme. The highway drainage will be installed to maintain the reduced groundwater level. This may impact groundwater level and flows within the vicinity of the cutting.

3.4.6 The baseline conditions review identified a number of groundwater features, tributaries, streams and drainage features within 500m of the proposed Cutting 3, as detailed below. The features are shown on Volume 2, Figure 7.5.

Table 4 Features identified within 500m of the proposed Cutting 3 (1+490 to 1+780) at 87mOD at western end to 91mOD at eastern end.

ID	Feature type	Chainage	Approximate distance to Cutting 3	Approximate ground elevation, mOD	Potential for impact
GW6	Issues	1+150	480m NW	86	No
GW7	Headwaters of unnamed tributary of Longford Brook;	1+590	130m N	93	Yes
GW8	Spring	1+150	350m NW	87	No
GW16	GWDTE Woodland habitat (W6)	1+400	online	70-75	No
A	Pond	1+779	75m SE	86	No

3.4.7 Features GW7, GW16 and Pond A are all located at lower elevation than the construction depth (87-91mOD, east to west) and therefore any dewatering activities or drainage are unlikely to impact the groundwater regime within which these features lie.

3.4.8 A spring (GW8) is located some 350m north west of the proposed cutting at 87mOD, approximately at the same elevation as the western end of the cutting. Considering the distance to the cutting it is unlikely that groundwater level will be impacted at that location.

3.4.9 Feature GW7, headwaters of unnamed tributary of Longford Brook, is located on the fault line at a level of 93mOD. It is therefore likely that its baseflow is largely dependent on groundwater conveyed through the fault zone. The proposed maximum cut is below the feature level. Therefore, there is potential that lowering of the groundwater table may impact the base flow.

3.5 Summary

3.5.1 Construction of the cuttings has a potential to locally impact hydrogeology by influencing groundwater levels, gradient and flow rates as a result of either dewatering works or drainage. The initial assessments of the potential impacts on groundwater dependent features identified three features where there is a potential for the cuttings to impact groundwater flows and levels. These are summarised in Table 5 below.

Table 5 Identified features potentially impacted by construction of cuttings

ID	Feature type	Approximate distance to cutting causing potential impact	Approximate ground elevation, mOD	Base flow affected	Direct surface water catchment
GW7	Headwaters of unnamed tributary of Longford Brook;	Cutting 3 130m N	93	GW	Longford Brook
GW14	Headwaters of unnamed tributary of Narberth Brook	Cutting 1 40m N	96	GW/ SW run-off	Narberth Brook
E	Pond	Cutting 1 130m S	101	GW	

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