Industrial Emissions Directive – Hayle Waste Water Treatment Works (WWTW)

Site Condition Report – H5

September 2022

Prepared for:

South West Water

Prepared by:

Stantec UK

South West Water

INDUSTRIAL EMISSIONS DIRECTIVE – HAYLE WASTE WATER TREATMENT WORKS (WWTW)

Site Condition Report – H5

Revision	Description	Author		Quality Check		Independent Review	
01	H5 SCR	E Wilson		R Gordon		P Duncan	

South West Water

INDUSTRIAL EMISSIONS DIRECTIVE – HAYLE WASTE WATER TREATMENT WORKS (WWTW)

Site Condition Report – H5

South West Water

Table of Contents

1.0 SITE DETAILS

Name of the applicant	South West Water Services Limited
Activity address	Hayle Sewage Treatment Works Station Approach St Erth Hayle TR27 6LA United Kingdom
National grid reference	Approximate Sewage Treatment Works: SW546357 (coordinates: 154679, 035721)
Document reference and dates for Site Condition Report at permit application and surrender	Reference: Site Condition Report H5 TBC 2022 Application Date: September 2022
Document references for site plans (including location and boundaries)	Stantec Industrial Emissions Directive Compliance Action Plan, Environmental Qualitative Risk Assessment, Hayle Waste Water Treatment Centre, Report Reference: 330202255, version 1.0, September 2022. Figure 2.1 Site Setting – Regional Figure 2.2 Site Setting – Local Figure 3.1 Sludge Treatment Process Flow Diagram Figure 3.2 Plan of Current Sewage Treatment Centre Assets (& shows site surfacing) Figure 4.1 Site investigation borehole locations Figure 4.2 Surface Water Features

2.0 CONDITION OF THE LAND AT PERMIT ISSUE

Environmental setting including: • geology • hydrogeology • surface waters	The environmental setting of the Sewage Treatment Works has been detailed in the Environmental Quantitative Risk Assessment (EQRA) completed for the site (Stantec, 2022). The Hayle Sewage Treatment Works is located in a mixed urban / rural area close to the residential areas of St Erth c. 1 km to the south-east and Hayle c. 2.5 km to the north-east. The Sewage Treatment Works covers an area of 7 ha which includes the assets that comprise the Waste Water Treatment Works (1.67 ha of this) and the assets used for the treatment of wastewater, both operated by South West Water Services Limited (SWWSL).

	Geological, hydrogeological and hydrological information detailed within the EQRA is based upon previous Site Investigation (SI) reports completed for developments across the Sewage Treatment Works. Locations of the previous SI and available British Geological Survey (BGS) borehole logs are presented on Figure 4.1. Site Investigation Locations are as follows: Geotechnical Engineering Ltd (2016) - two boreholes (BH01 and BH02) Located to the east of the Site (as shown on Figure 4.1). Arcadis (2016) - three boreholes (BH01 to BH03) Located to the west of the building containing the generators [V] (as shown on Figure 4.1). BGS Borehole Logs - nine boreholes (SW53NW61 – SW53NW58, SW53NW55, SW53NW52, SW53NW49, SW53NW48, SW53NW46) Located within 250 of the Site (as shown on Figure 4.1). **Geology** *Made Ground* Made Ground has been identified in all the boreholes in the wider Sewage Treatment Works with thicknesses of approximately 3 m in the east and between approximately 2 and 4 m in the west. The Made Ground is described as consisting predominantly of sand and gravel with layers of clay; the absence of man-made materials (e.g., concrete) suggested that it is likely that this Made Ground was deposited prior to the development of the sewage works and may be associated with mine workings that are thought to pre-date it. *Superficial Quaternary Deposits: Alluvium and Tidal Flat Deposits* The Cake Storage Barn [T] is located in the north-east of the Site where, Made Ground is underlain by superficial deposits (which as indicated by the geological mapping appear to be associated with an infilled valley underlying the River Hayle). The superficial deposits are recorded in both boreholes drilled by Geotechnical (2016) in this area as being up to approximately 10 m thick and are comprised of a range of peat, clayey silt and sand which is identified as Alluvium. This is likely to transition into the Tidal Flat Deposits to the north towards the estuary. T.

Similar superficial deposits are also confirmed to be present to the south of the Site (beneath the area of woodland known as Lower Covert) as recorded in BGS borehole SW53NW52. The 5 m depth recorded stony clay with pockets of peat and gravel which also suggests Alluvium superficial deposits are present.

Mylor Slate Formation

The Made Ground lies directly above the bedrock in the west of the Sewage Treatment Works with the Mylor Slate Formation being described as weak to medium strong grey slate with more clayey units in between which is fractured in places. Most of the sludge assets within the Site are believed to be located where this is the case.

Hydrogeology

Aquifer Designations

The Alluvium in the east / south of the Site and the Mylor Slate Formation are classified as Secondary A aquifers and the Tidal Flat Deposits are a Secondary undifferentiated aquifer. This is due to permeable layers they contain being capable of supporting water supplies at a local scale.

Aquifer Testing

Geotechnical (2016) report that constant head laboratory testing was undertaken on two core samples taken from the alluvium at a depth of 4.1 to 4.2 m in BH01 (described as a silty clay) and at a depth of 5.5 to 5.6 m in BH02 (described as a clayey silt). The results were 5.6×10^{-10} m/s and 1.1×10^{-9} m/s respectively (which are indicative of the fine grained materials that were typically encountered within the alluvium).

Source Protection Zones

There are no Source Protection Zones within 500 m of the Site; the nearest is over 3 km to the south-west.

Licenced Groundwater Abstractions

The EA has provided information on 10 licenced groundwater abstractions within 4 km of the Site. The closest groundwater abstraction (15/49/252/G/066) is operated by SWWSL and is located in the south-eastern corner of the Site for processing. It has an annual volume of 37,823 m^3 and maximum daily volume of 145.4 m^3. However, it is understood from SWWSL that this abstraction is not currently used.

Groundwater Observations

	Groundwater strikes were not recorded during drilling and no groundwater monitoring has been carried out during either of the two site investigations that have been performed at the Site. Three out of nine BGS boreholes within 250 m of the Site recorded groundwater during drilling and these were the deepest boreholes (15 – 27.67 m depth). Groundwater was first struck in SW53NW48 at 2 m below ground level (bgl) within the superficial deposits and rested at just above 1 m bgl (approximately 1 mAOD). Similarly, groundwater was struck in BGS borehole SW53NW49 at just above 1 m bgl (approximately 1 mAOD). The rest water level in the third borehole recording groundwater (SW53NW46) is at approximately -0.32 mAOD which is slightly lower but is closer to the estuary / coast than the previous two boreholes. Therefore, this suggests a shallow groundwater table is present within the superficial deposits (Alluvium) underlying the river. A further BGS borehole (SW53NW52) noted that the water level was standing at ground level and due to its location within the streams in the Lower Covert plantation it would imply that the shallow groundwater in the Alluvium channel continues to the south of the Site. The River Hayle to the east is around 2 mAOD and the streams within Lower Covert plantation to the south are around 3 mAOD which suggests these surface water features are likely to be in hydraulic continuity with the shallow groundwater in the Alluvium. Due to the fractured nature of the Mylor Slate Formation it is likely the shallow groundwater table in the Alluvium passes horizontally into the adjacent bedrock where superficial deposits are absent and there is a fairly flat hydraulic gradient between the two units. Further information on groundwater is included in the EQRA (Stantec, 2022). **Surface Waters (Hydrology)** Surface water in the area is expected to generally drain to the east and south towards the River Hayle and its tributaries following the local topography. The are no surface water features present on the Site itself, however various streams and issues are located within the Lower Covert plantation to the south of the Site which flow in an easterly direction towards a large pool and the River Hayle. The closest issue and stream to the Site are located around 30 m to the south-west. Two smaller pools are located within the plantation close to the Site with the large pool lying

	to adjacent to the southern boundary of the STW / immediately to the west of the River Hayle.
Pollution history including: • pollution incidents that may have affected land • historical land-uses and associated contaminants • any visual/olfactory evidence of existing contamination • evidence of damage to pollution prevention measures	**Pollution Incidents** There are three historic pollution incidents recorded by the EA within 500 m of the Site. Of these records, one is within 100 m of the Site, but none relate to sewage materials and none have had an impact on the water. The closest was 84 m north-east of the Site and released atmospheric pollutants. The other pollution incidents recorded in the local area appear to relate to other commercial / industrial premises in the local area (records are provided in the EQRA (Stantec, 2022) Appendix A). **Historical land-uses & associated contaminants** Historical mapping is provided in Appendix B and Appendix C of the EQRA (Stantec, 2022). Potentially contaminative activities / features are listed in Appendix A of the EQRA. ***Sewage Works*** The Site was established initially as a sewage works in the 1960s or early 1970s but in the southern / eastern part of the Site only. St Erth Refuse Transfer Station (which is located immediately to the north-west of the Site) was also first developed at a similar time. Prior to this time the area was occupied by a road related to a dwelling which was located in the wooded area to the south-east of the Site; various old shafts are identified in the area to the west of the Site suggesting that historic mine workings have occurred in the surrounding area. A small pit is also marked on 1908 and 1936 mapping in the north-east of the Site. The sewage works were extended to the north in the 1990s to cover the majority of the current Site area. The northern part of the Site (now occupied by the Cake Storage Barn [T] was first developed in the 2000s. Parts of the Site have been raised with land surrounding tanks being sloped. This has been the case since the Site was initially developed and is most prominent along the southern and eastern boundaries of the sewage works. Similarly, the banks along the River Hayle appear to have been sloped between 1936 and 1958. ***Waste Management Licences/Landfills*** No historical landfills are located within 500 m of the Site. ***Potential Contaminants*** Potential contaminants associated with the identified potential sources of contamination on site and in the surrounding area include:

	Metals, petroleum hydrocarbons - associated with fuel tank(s) and pumping stations relating to the sewage works; PAHs, polychlorinated biphenyls (PCBs) (associated with possible generators and electricity substations), Metals, asbestos and ground gas (carbon dioxide, carbon monoxide) - from areas of Made Ground and sewage treatment, Predominantly metals (and possibly alkalis and mineral/organic acids) from nearby historic mine workings at the Site and potentially associated mine waste materials. Further detail on the potential sources of contamination (PSC) and contaminants associated with current and historical use of the Site and other potential sources of contamination (PSC) identified within 50m of the Site (250m for infilled ground/ landfill) with an accompanying PSC Plan is included in the memorandum titled, *Potential Sources of Contamination Hayle Sewage Treatment Works, Waste Water Treatment Works – Supporting Information for H5 Site Condition Report* (Stantec, 2022) presented as Appendix A of this document. **Visual / Olfactory Evidence of Contamination** No olfactory evidence of contamination was identified during the July 2021 site visit. As detailed within the EQRA, visual evidence of contamination included leakages from the macerator pumps, centrifuge feed pumps and centrifuge. Made Ground was identified across the Site. In general, there was an absence of man-made materials. However, clinker was noted in between 0.8 and 1.4 m bgl in BH02 during the Geotechnical 2016 SI. No other visual or olfactory evidence of contamination was noted. **Evidence of Damage to Pollution Prevention Measures** Within the EQRA, Table 3.1 Main Assets Associated with Sludge Treatment (observations made and information obtained during site visit) indicates that no failure has occurred at the WWTW at the time of the inspection.
Evidence of historic contamination, for example, historical site investigation, assessment, remediation and verification reports (where available)	Both previous SI reports for the Site include very limited geo-environmental chemical testing data. In the soils, only pH and major ions were tested in these investigations. For detail on contamination encountered during previous SI at the site see the *Potential Sources of Contamination Hayle Sludge Treatment – Supporting Information for H5 Site Condition Report (Stantec, 2022)* presented in Appendix A of this document.
Baseline soil and groundwater reference data	For detail of the soil and groundwater reference data at the Site see the *Potential Sources of Contamination Hayle Waste Water Treatment Works – Supporting Information for H5 Site Condition Report (Stantec, 2022)* presented in Appendix A of this document. As presented in Table 1.3 of the report in Appendix A there are potential contaminants (most likely metals, PAHs and TPHs) associated with the historical mining land uses and current WWTW activities at the Site. As

	only limited SI data is currently available for the site, it is recommended that further SI is undertaken to provide a more comprehensive baseline.
Supporting information	• Source information identifying environmental setting and pollution incidents • Historical Ordnance Survey plans • Site reconnaissance • Historical investigation / assessment / remediation / verification reports • Baseline soil and groundwater reference data

3.0 PERMITTED ACTIVITIES

Permitted activities	STW comprising Sludge Treatment Process outlined in the EQRA Section 3.1 Figure 3.1 Sludge Treatment Process Flow Diagram (Stantec, 2022).
Non-permitted activities undertaken	Not Applicable
Document references for: • plan showing activity layout; and • environmental risk assessment.	Stantec Industrial Emissions Directive Compliance Action Plan, Environmental Qualitative Risk Assessment, Hayle Waste Water Treatment Centre, Report Reference: 330202255, Version 1.0, September 2022. Figure 2.1 Site Setting – Regional Figure 2.2 Site Setting – Local Figure 3.1 Sludge Treatment Process Flow Diagram Figure 3.2 Plan of Current Sewage Treatment Centre Assets Table 3.1 Main assets associated with Sludge Treatment Section 6.0 EQRA.

Note:

In Part B of the application form you must tell us about the activities that you will undertake at the site. You must also give us an environmental risk assessment. This risk assessment must be based on our guidance (*Environmental Risk Assessment - EPR H1*) or use an equivalent approach.

It is essential that you identify in your environmental risk assessment all the substances used and produced that could pollute the soil or groundwater if there were an accident, or if measures to protect land fail.

These include substances that would be classified as 'dangerous' under the Control of Major Accident Hazards (COMAH) regulations and also raw materials, fuels, intermediates, products, wastes and effluents.

If your submitted environmental risk assessment does not adequately address the risks to soil and groundwater we may need to request further information from you or even refuse your permit application.

4.0 CHANGES TO THE ACTIVITY

Have there been any changes to the activity boundary?	This application is for a new installation comprising existing activities.
Have there been any changes to the permitted activities?	If yes, provide a description of the changes to the permitted activities

Have any 'dangerous substances' not identified in the Application Site Condition Report been used or produced as a result of the permitted activities?	If yes, list of them
Checklist of supporting information	• Plan showing any changes to the boundary (where relevant) • Description of the changes to the permitted activities (where relevant) • List of 'dangerous substances' used/produced by the permitted activities that were not identified in the Application Site Condition Report (where relevant)

5.0 MEASURES TO BE TAKEN TO PROTECT LAND

Use records that you collected during the life of the permit to summarise whether pollution prevention measures worked. If you can't, you need to collect land and/or groundwater data to assess whether the land has deteriorated.	
Checklist of supporting information	• Inspection records and summary of findings of inspections for all pollution prevention measures • Records of maintenance, repair and replacement of pollution prevention measures

6.0 POLLUTION INCIDENTS THAT MAY HAVE HAD AN IMPACT ON LAND, AND THEIR REMEDIATION

Summarise any pollution incidents that may have damaged the land. Describe how you investigated and remedied each one. If you can't, you need to collect land and /or groundwater reference data to assess whether the land has deteriorated while you've been there.	
Checklist of supporting information	• Records of pollution incidents that may have impacted on land • Records of their investigation and remediation

7.0 SOIL GAS AND WATER QUALITY MONITORING (WHERE UNDERTAKEN)

Provide details of any soil gas and/or water monitoring you did. Include a summary of the findings. Say whether it shows that the land deteriorated as a result of the permitted activities. If it did, outline how you investigated and remedied this.	
Checklist of supporting information	• Description of soil gas and/or water monitoring undertaken • Monitoring results (including graphs)

8.0 DECOMMISSIONING AND REMOVAL OF POLLUTION RISK

Describe how the site was decommissioned. Demonstrate that all sources of pollution risk have been removed. Describe whether the decommissioning had any impact on the land. Outline how you investigated and remedied this.	
Checklist of supporting information	• Site closure plan • List of potential sources of pollution risk • Investigation and remediation reports (where relevant)

9.0 REFERENCE DATA AND REMEDIATION (WHERE RELEVANT)

Say whether you had to collect land and/or groundwater data. Or say that you didn't need to because the information from sections 3, 4, 5 and 6 of the Surrender Site Condition Report shows that the land has not deteriorated. If you did collect land and/or groundwater reference data, summarise what this entailed, and what your data found. Say whether the data shows that the condition of the land has deteriorated, or whether the land at the site is in a "satisfactory state". If it isn't, summarise what you did to remedy this. Confirm that the land is now in a "satisfactory state" at surrender.	
Checklist of supporting information	• Land and/or groundwater data collected at application (if collected) • Land and/or groundwater data collected at surrender (where needed) • Assessment of satisfactory state • Remediation and verification reports (where undertaken)

10.0 STATEMENT OF SITE CONDITION

Using the information from sections 3 to 7, give a statement about the condition of the land at the site. This should confirm that:

- the permitted activities have stopped
- decommissioning is complete, and the pollution risk has been removed
- the land is in a satisfactory condition.

APPENDIX A

Potential Sources of Contamination – Supporting Information

Stantec

Memo

To:	South West Water	From:	Stantec
File:	330201825 SWW IED HRAs	Date:	September 22, 2021

Reference: Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.

BACKGROUND

South West Water Services Limited (SWWSL) is required to meet conditions under the Industrial Emissions Directive (IED). An environmental permit is required for the Sludge Treatment Centre (STC) (the Site) located within Hayle Sewage Treatment Works (STW).

As part of the environmental permit application an Environmental Quantitative Risk Assessment (EQRA) (Stantec, 2021), has been undertaken for the Hayle STC. The EQRA provides a Compliance Action Plan (CAP) detailing the site specific actions required at the Hayle STC to ensure IED compliance. The EQRA will be used to identify the mitigation measures that are required to reduce the risk of pollution to ground or local water environment to comply with the IED. To support the EQRA process, a desk-top preliminary hydrogeological study for the Hayle STC has been undertaken and is presented within the EQRA.

In addition to the EQRA, an H5 Site Condition Report (SCR) (Stantec, 2021) has been completed for the Hayle STC. The purpose of the SCR is to describe and record the baseline conditions of the land and groundwater at the Site at the point of application/ start of operations.

To support the SCR, this memo documents a review of environmental data to identify potential sources of contamination at the Site and within the surroundings, resulting from historical and/ or current land uses/ activities.

This memo should be read in conjunction with the SCR and EQRA.

SITE SETTING

The Site is located at:

Hayle Sewage Treatment Works
Station Approach
St Erth
Hayle
TR27 6LA.

National Grid Reference: (approximate STW centre): SW546357; Coordinates: 154679, 035721.

The Site is located in a mixed urban / rural area close to the residential areas of St Erth c. 1 km to the south-east and Hayle c. 2.5 km to the north-east. A railway line is situated close to the northern boundary of the Site with St Erth station located approximately 400 m to the west; the River Hayle lies adjacent to the eastern boundary and a woodland plantation (Lower Covert) is located to the south / west of the Site.

The A30 road lies 200 m north of the Site at its closest approach. The River Hayle is situated immediately to the east of the Site where it flows northwards into the Hayle Estuary c. 400 m to the north of the Site which then discharges into the Celtic Sea c. 3 km further to the north. Figure 2.2 shows the local setting of the Site.

Reference: **Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.**

Further information on site setting, including geology, hydrogeology and hydrology is provided in the EQRA.

HISTORICAL GROUND INVESTIGATION

Reports for 2 Site Investigations (SI) have been provided for the Hayle STW.

- Geotechnical Engineering Ltd drilled two boreholes (BH01 and BH02) to the east of the Site (Geotechnical, 2016).
- Arcadis drilled three boreholes (BH01 to BH03) to the west of the building containing the generators [V] (Arcadis, 2016).

Figure 4.1 extracted from the EQRA shows the locations of the exploratory holes completed as part of the SIs, in addition to British Geological Survey (BGS) Boreholes available (BGS, 2021).

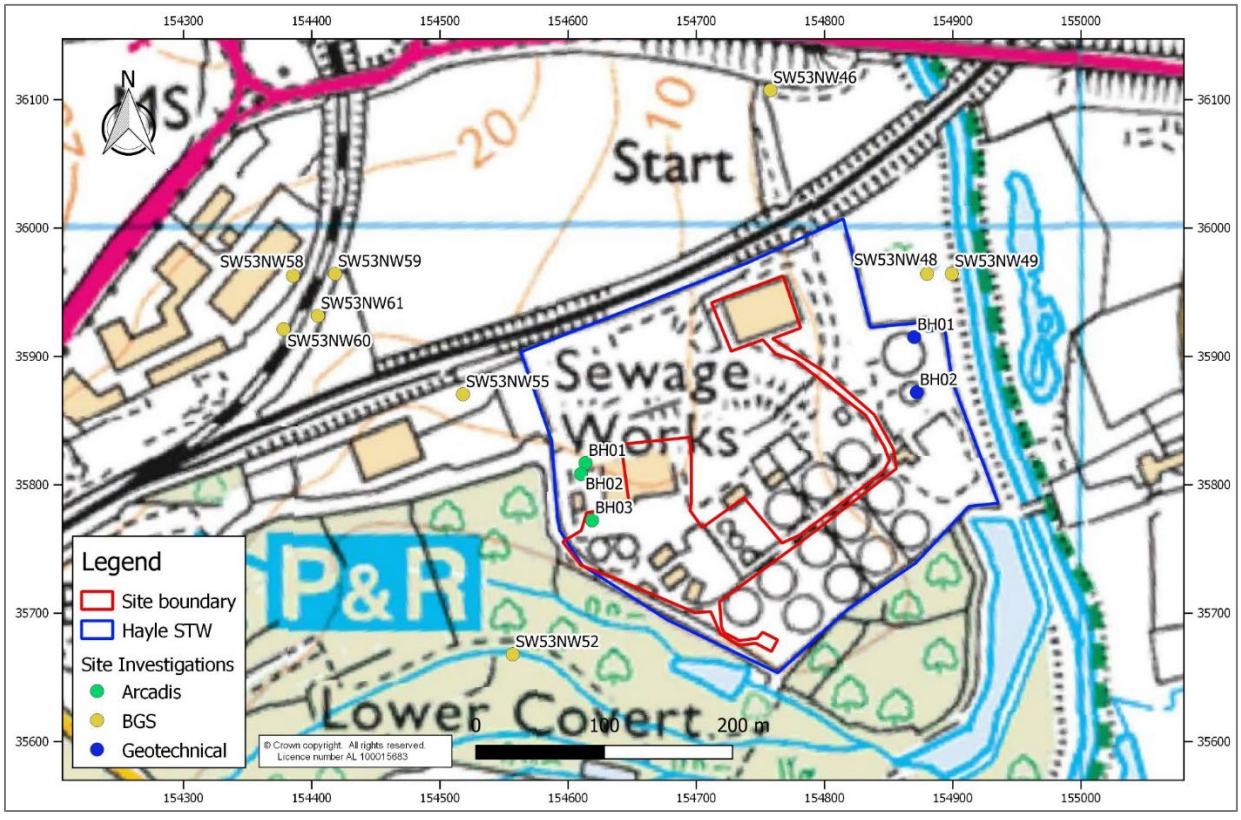


Figure 4.1 Previous Ground Investigations Exploratory Hole Location Plan (current STW boundary)

Strata Encountered

A review of the strata encountered as reported on the exploratory hole logs is detailed within the EQRA Section 4.0, but is also summarised as follows:

Reference: **Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.**

Made Ground

Made Ground has been identified in all the boreholes in the wider STW with thicknesses of approximately 3 m in the east and between approximately 2 and 4 m in the west. The Made Ground is described as consisting predominantly of sand and gravel with layers of clay; the absence of man-made materials (e.g., concrete) suggested that it is likely that this Made Ground was deposited prior to the development of the sewage works and may be associated with mine workings that are thought to pre-date.

Clinker was recorded in Made Ground in BH02 between 0.8m and 1.4m bgl during the Geotechnical 2016 SI, located to the east of the current STW.

No other visual/ olfactory evidence of contamination was noted in the exploratory hole records.

Superficial Deposits

The Cake Storage Barn [T] is located in the north-east of the Site where, Made Ground is underlain by superficial deposits (which as indicated by the geological mapping appear to be associated with an infilled valley underlying the River Hayle). The superficial deposits are recorded in both boreholes drilled by Geotechnical (2016) in this area as being up to approximately 10 m thick and are comprised of a range of peat, clayey silt and sand which is identified as Alluvium. This is likely to transition into the Tidal Flat Deposits to the north of the Site towards the estuary. Here, the underlying bedrock is described as a sequence of fractured laminated slate and siltstone and is recorded at around -6 m AOD.

Similar superficial deposits are also confirmed to be present to the south of the Site (beneath area of woodland known as Lower Covert) as recorded in BGS borehole SW53NW52. The 5 m depth recorded stony clay with pockets of peat and gravel which also suggests Alluvium superficial deposits are present

Bedrock

The Made Ground lies directly above the bedrock in the west of the STW with the Mylor Slate Formation being described as weak to medium strong grey slate with more clayey units in between which is fractured in places. Most of the sludge assets within the Site are believed to be located where this is the case.

Further information on the geology encountered during these SI at the STC and wider STW is provided in the EQRA.

Geo-Environmental Analysis

Both SI reports existing for the Site include geo-environmental chemical testing.

Table A1 presented in Appendix A summarises the geo-environmental soil samples available for review.

Soil Analysis

Reference: **Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.**

Laboratory analysis results from the Geotechnical Engineering Ltd 2016 SI is very limited but reported that all maximum concentrations were recorded in BH02 in the 5.2m sample. Magnesium and nitrate were not present above the laboratory limit of detection (LoD).

Detected maximum and minimum concentrations identified during the 2016 SI are summarised in Table 1.1.

Table 1.1 Summary of Detected Contaminant Concentrations in soils, Geotechnical 2016

Contaminant	Minimum	Exploratory Hole Location & Depth (m bgl)	Maximum	Exploratory Hole Location & Depth (m bgl)
pH	8.3	BH01 at 15m	9.0	BH02 at 5.2m
Sulphate	0.011 g/l	BH02 at 13.2m	0.26 g/l	BH02 at 5.2m
Total Sulphur	<0.01 %	BH01 at 1m, BH02 at 13.2m	0.63 %	BH02 at 5.2m
Chloride	<0.01 g/l	BH01 at 15m, BH02 at 13.2m	0.18 g/l	BH02 at 5.2m
Sulphate	<0.01 %	BH02 at 13.2m	0.17 %	BH02 at 5.2m

Arcadis only sampled for three parameters in 2016 during the geo-environmental laboratory analysis, these were stone content, moisture content and pH. Only pH is relevant to this report. In soils pH ranged from 7.5 in BH01 (2.8 - 2.9m depth) and 8.3 in BH02 at (1.8 - 1.9m depth) and BH03 (1.4 – 1.5 m depth).

During the geo-technical laboratory analysis sulphate, chloride, pH, sulphur, magnesium and nitrate were also tested for across nine soil samples. No magnesium or chloride were detected above their respective LoD. The sample from BH02 at a depth of 3 – 3.45 m recorded the majority of the maximum concentrations. The remaining maximum and minimum concentrations detected are summarised in Table 1.2.

Table 1.2 Summary of Detected Contaminant Concentrations in soils, Arcadis 2016

Contaminant	Minimum	Exploratory Hole Location & Depth (m bgl)	Maximum	Exploratory Hole Location & Depth (m bgl)
Acid Soluble Sulphate as SO4	0.14 %	BH01 at 5.7-6m	0.33 %	BH02 at 3-3.45m
Aqueous Extract Sulphate as SO4	0.02 g/l	BH01 at 5.7-6m	0.06 g/l	BH02 at 3-3.45m
pH	6.84	BH03 at 0.2-0.5m	8.11	BH01 at 8.8-9.8m
Total Sulphur SO4	0.06 %	BH01 at 5.7-6m, BH03 at 0.2-0.5m	0.12 %	BH02 at 3-3.45m
Nitrate NO3	<10 mg/l	BH01 at 8.8-9.8m, BH02 at 0.5-1m, BH03 at 0.2-0.5m, BH03 at 1.7-2.7m	25 mg/l	BH02 at 3-3.45m

Reference: **Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.**

Information provided by SWWSL and detailed within the EQRA (Stantec, 2021) shows the composition of the final cake at the STC during bi-monthly sampling March 2020 to May 2021. No comparison can be made between the final cake and either SI as there are no consistent determinands analysed for between them with the exception of pH. Therefore, a baseline cannot be determined. The pH range in the final cake was 6.6 – 8.8 compared in soils to 8.3 – 9 in Geotechnical (2016) and 6.84 – 8.11 in Arcadis (2016) which are all similar.

Groundwater Sample

No groundwater samples were collected during either SI.

It should be noted that a great deal of emphasis is placed on the limited chemical data and the reported data shouldn't be assumed to represent ground quality at the Site. The chemical data is for samples collected by a third party; sample collection and storage procedures are not known and could affect the validity of the results. Furthermore, chemical concentrations vary spatially and with time.

The laboratory analysis reports are appended to the individual SI Reports, presented as Appendix B and C of this memo (Stantec, 2021).

POTENTIAL SOURCES OF CONTAMINATION (PSCs)

PSCs identified on site and within 50m of the Hayle STW (250m for potentially infilled ground) are summarised in Table 1.3 and illustrated in Figure 1. This has been completed by reviewing the site history presented in the EQRA and using information, including historical mapping included in the Environmental Data Report (Groundsure, 2021) and online sources (Data.gov.uk, 2021).

Table 1.3 Potential Sources of Contamination (PSCs)

PSC Plan ID	PSC on site or within 50m radius, 250m radius for potentially infilled land	Distance to site	Status / Year	Potential Contaminants
1	Hayle STC. Infrastructure includes digesters, sludge screens, centrifuges, diesel storage tanks, polymer make-up tanks and boiler including fuel oil storage tank (see EQRA Figure 3.2 For Current STC Assets). Clinker was recorded in Made Ground in BH02 between 0.8m and 1.4m bgl during the Geotechnical 2016 SI, located to the east of the current STW (see Figure 4.1 for BH02 location).	On-Site	Present	Metals, petroleum hydrocarbons, VOCs including BTEX, MTBE - associated with fuel tank(s) and pumping stations Phenols, PAHs, pathogens, polychlorinated biphenyls (PCBs) (associated with generators and electricity substations), Asbestos and ground gas (carbon dioxide, carbon monoxide, methane, hydrogen sulphide) - from areas of infilling and sewage treatment, Volatile organic vapours – from storage tanks
1a	Wider Hayle STW. Sewage works, unspecified tanks and unspecified ground workings (PSC 1b) (c. 1985) in the south-east. STW expands slightly to the north-west in c.2001 and to cover the entire site area. Made Ground was identified in all the SI boreholes around 3m thick in the east and 2 to 4m thick in the west of the STW (see Figure 4.1 for locations). There is a general absence of man-made materials suggesting this Made Ground was deposited prior to development of sewage works and are associated with mine workings.	Adjacent	1960s to present	
1b	Tanks / Unspecified tanks	On-site	c. 1985	Metals, petroleum hydrocarbons, VOCs, including BTEX, MTBE - associated with fuel tank(s) and pumping stations Phenols, PAHs, pathogens, PCBs, ground gas (carbon dioxide, carbon monoxide, methane, hydrogen sulphide) – associated with sludge beds
	Unspecified ground workings / sewage works / unspecified heap / unspecified old shaft			
1c	Historic metal mining and surface ground workings with related mine waste and spoil. Underground mining is known / is likely to have occurred at the Site with unspecified old shafts supporting this. Tin mining has been reported to have occurred.	On-site	Pre-1877	Metals, alkalis, mineral acids, organic acids, oils/fuels, organic solvents, inorganic compounds
Landfills (or waste facilities) within 250m; pollution incidents within 50m (Groundsure, 2020) (Data.gov.uk, 2021)				
2	Refuse Transfer Station approximately 7m north of Site and Waste Transfer Stations approximately 15m north-west of Site at Treloweth Lane and 25m north-west at St Erth Transfer Station			
N/A	Pollution incidents – none recorded within 50m			
British Geological Survey (BGS) Online Records (artificial ground within 250m)				
N/A	No Made Ground present on mapping			
Environmental Permitting / Exemptions (50m radius)(Groundsure, 2021)				
N/A	Environmental Permit held for treating waste exemptions held by South West Water for recovery of waste at the STW for non-agricultural waste only. Two further treating waste exemptions for the recovery of waste at the STW and a using waste exemption for use of waste in construction at the STW are held by South West Water.			

Reference: **Potential Sources of Contamination – Hayle Sewage Treatment Works, Sludge Treatment Centre – Supporting Information for H5 Site Condition Report, Version 1.**

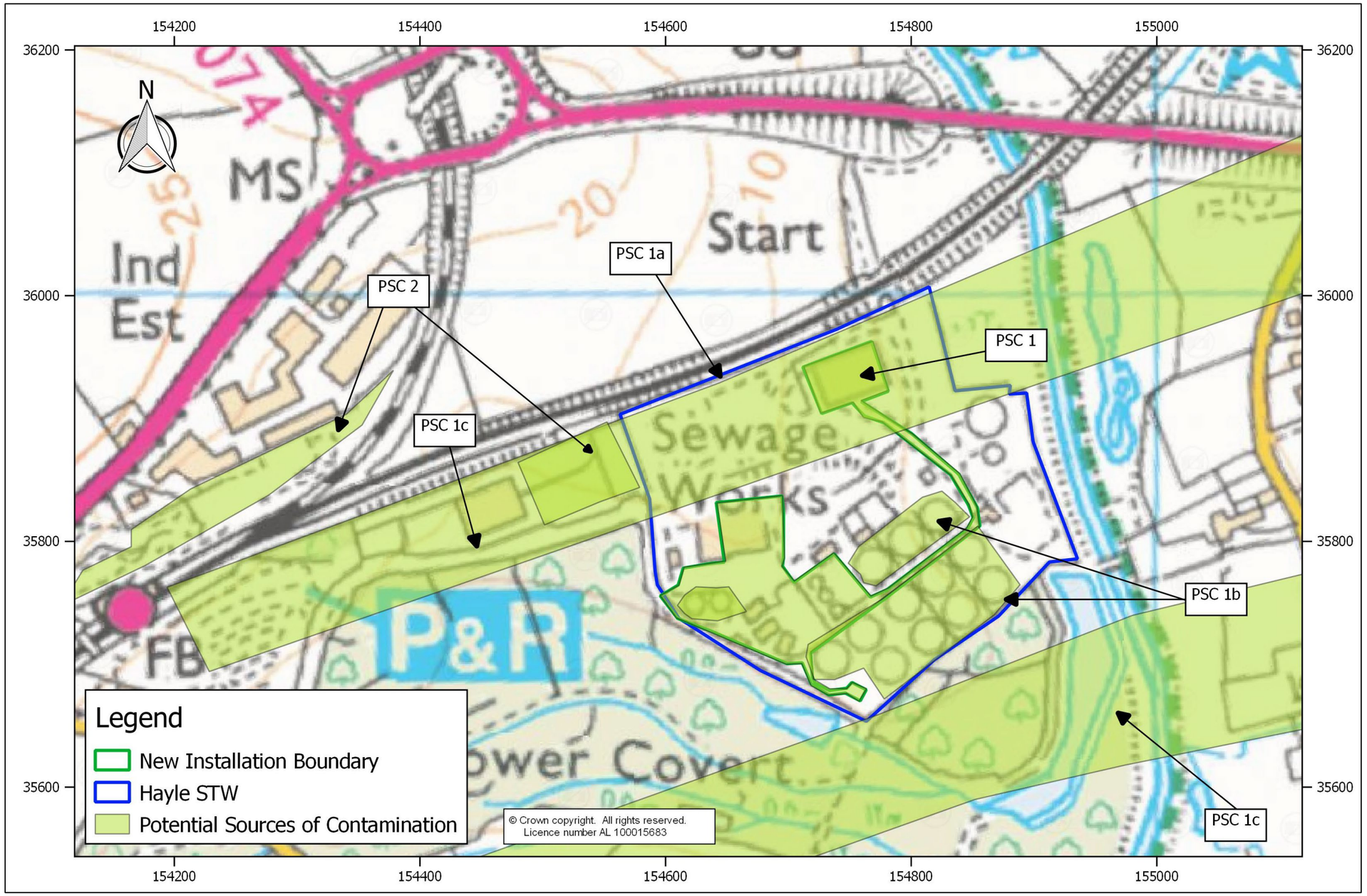


Figure 1 Potential Sources of Contamination (PSC) Plan (original STC boundary)

RECOMMENDATIONS FOR BASELINE DATA

A number of potential sources of contamination (PSCs) have been identified on Site. As presented in Table 1.3, there are potential contaminants associated with both the STC activities at the Site, the wider STW and historic mine workings. As only very limited SI data is currently available for the site, it is recommended that further SI is undertaken to provide a more comprehensive baseline.

It is recommended that both soil and groundwater and potentially vapour samples are collected during the SI and the suites of analysis include, but may not be limited to, the contaminants listed in Table 1.3.

REFERENCES

Stantec, Industrial Emissions Directive Compliance Action Plan Environmental Quantitative Risk Assessment, Hayle Waste Water Treatment Centre, Reference: 330202255, version 1.0, September 2022 (Stantec, 2022).

Stantec, Hayle Waste Water Treatment Works, Site Condition Report – H5, version 1.0, September 2021 (Stantec, 2021).

Groundsure Report, Location 154678, 35780, Reference: EPL003956/ GS-8020156, 6th July 2021 (Groundsure, 2021).

Open access Environment Agency Data on gov.uk (Data.gov.uk, 2021).

Geology of Britain viewer. https://www.bgs.ac.uk Geological Survey (BGS). Last accessed 22 September 2021 (BGS, 2021).

QUALITY ASSURANCE

Version 1 Author: Elizabeth Wilson Checker: Rob Gordon Reviewer: P Duncan	

Appendix A – Data Tables

Table A1 Historical GI Geo-Environmental Analysis

Exploratory Hole ID	Sample Depth	Strata	Suites of Analysis					
			Moisture	pH	Magnesium	Sulphate, Sulphur	Chloride	Nitrate
Geotechnical Engineering Ltd 2016 – Soil Samples								
BH01	1.0m	Made Ground	X	X	X	X	X	X
	15m	SILTSTONE (MSF)	X	X	X	X	X	X
BH02	5.2m	SILT (MSF)	X	X	X	X	X	X
	13.2m	SLATE (MSF)	X	X	X	X	X	X
Exploratory Hole ID	Sample Depth	Strata	Moisture content, stone content	Sulphate content, Sulphur	pH	Chloride content	Magnesium	Nitrate NO3
Arcadis 2016 – Soil Samples								
BH01	2.2m	Made Ground		X	X	X	X	X
	5.7-6.0m	CLAY (MSF)		X	X	X	X	X
	8.8-9.8m	CLAY (MSF)		X	X	X	X	X
BH02	0.5-1.0m	Made Ground		X	X	X	X	X
	3.0-3.45m	Made Ground		X	X	X	X	X
	5.3-6.8m	SLATE (MSF)		X	X	X	X	X
	6.8-7.9m	SLATE (MSF)		X	X	X	X	X
BH03	0.2-0.5m	Made Ground		X	X	X	X	X
	1.7-2.7m	SLATE (MSF)		X	X	X	X	X
BH01	0.5-1.0m	Made Ground	X		X			
	2.8-2.9m	Made Ground	X		X			
	8.2-8.3m	CLAY (MSF)	X		X			
BH02	0.5-1.0m	Made Ground	X		X			
	1.8-1.9m	Made Ground	X		X			
	2.0-2.7m	Made Ground	X		X			
BH03	0.2-0.5m	Made Ground	X		X			
	0.5-1.0m	Made Ground	X		X			

	1.4-1.5m	Made Ground	X		X			

MSF – Mylor Slate Formation

Appendix B – Geotechnical Engineering Ltd GI, 2016

HAYLE SEWAGE TREATMENT WORKS

FACTUAL REPORT ON GROUND INVESTIGATION

Prepared for SOUTH WEST WATER

Report Ref: 32071

Geotechnical Engineering Ltd
Centurion House, Olympus Park
Quedgeley, Gloucester. GL2 4NF

01452 527743
www.geoeng.co.uk

Geotechnical Engineering Limited
www.geoeng.co.uk

HAYLE SEWAGE TREATMENT WORKS

FACTUAL REPORT ON GROUND INVESTIGATION

Prepared for SOUTH WEST WATER

Report Ref: 32071

PROJECT: Hayle Sewage Treatment Works

CONSULTANT: PELL FRISCHMANN

VOLUME - VERSION	STATUS	ORIGINATOR	CHECKER	APPROVED	DATE
1 of 1 – A	DRAFT	BC	CT	-	15/07/16
1 of 1 – A	FINAL	BC	CT	CT	28/07/16

ORIGINATOR	APPROVER
	
B CORRIGAN Senior Engineering Geologist	C THOMAS Senior Geotechnical Consultant

The report is not to be used for contractual or engineering purposes unless this sheet is signed and the report designated “Final”.
The report has been prepared for the sole use and reliance by South West Water. GEL accepts no liability as a result of the use or reliance of this report by any other parties.

CONTENTS

REPORT **PAGE**

FIGURES **Nos.**

APPENDICES

1. INTRODUCTION

It is proposed to expand the site at Hayle Sewage Treatment Works. Geotechnical Engineering Limited (GEL) was instructed by Pell Frischmann (the Consultant) acting on behalf of South West Water (the Client) to carry out an investigation to determine the ground conditions.

The scope of works and terms and conditions of appointment were specified by the Consultant and GEL correspondence reference T23879. The investigation was carried out under direction and supervision of the Consultant.

This report describes the investigation and presents the findings.

2. SITE LOCATION AND GEOLOGY

The site is situated at Hayle Sewage Treatment Works, south of the town of Hayle in Cornwall and may be located by its National Grid co-ordinates SW 548 359.

British Geological Survey (BGS) England and Wales (Sheet No. 351 and 358, 1:50,000, 1984) and the BGS online geology (1:50,000) indicate the site is underlain by superficial alluvium overlying the Mylor Shale Formation. Igneous intrusions have been intersected historically in regional boreholes.

3. GROUND INVESTIGATION

3.1 Fieldwork

The fieldwork was carried out in general accordance with BS5930:2015 during the period 13th to 17th June and comprised two boreholes.

The exploratory hole locations were selected by the Consultant and set out by this Company. The ground level and co-ordinates at each exploratory hole was established by this Company using GPS techniques.

The boreholes, referenced BH01 and BH02 (Appendix A), were formed using a track-mounted Geotechnical Pioneer Rig. Initially, an inspection pit was hand excavated at BH01 and BH02 to 1.00 and 1.20m respectively to check for buried services. Disturbed samples were taken and retained in a combination of plastic tubs, bags and glass jars. Heavy duty dynamic sampling techniques were then employed to produce a continuous disturbed sample of 112mm and 97mm nominal diameter reducing to 97mm (BH02 only) as the borehole was advanced. The samples were recovered in semi-rigid plastic liner.

On refusal to dynamic sampling the boreholes were continued by rotary core drilling techniques utlising a water flush. A double-tube swivel core barrel with semi-rigid plastic liner was utilised to recover a continuous sample of 90mm diameter.

The dynamic samples and rotary core were extracted horizontally from the sampler and core barrel respectively, the semi-rigid liner was cut to length and caps placed at each end to retain moisture content. All samples and core were retained in sequence in labelled, wooden coreboxes.

Standard penetration tests (SPT) were carried out in general accordance with BS EN ISO 22476-3:2005+A1:2011. A split barrel or a solid cone was used depending upon the materials encountered and the split barrel samples retained in airtight jars. The SPT N value was taken as the number of blows to penetrate the 300mm test drive following a 150mm seating drive. Where low penetration was recorded the seating drive was terminated at 25 blows and the test drive completed after a further 50 blows. Detailed SPT results, together with the energy ratio (E_r), are presented in Appendix A and summarised as uncorrected N values on the borehole logs.

Boreholes were monitored for groundwater ingress as dynamic sampling proceeded. Water levels were also recorded at the start and finish of each day's work and on completion of the borehole and are presented on the relevant log.

Variable head permeability tests were attempted in BH01 in general accordance with the procedures given in BS EN ISO 22282-2:2012. Falling head tests were carried out by topping up the borehole with clean water. Coefficients of permeability were not able to be calculated from the results.

On completion slotted standpipes were installed in BH01 and BH02. Each standpipe consisted of a 50mm ID PVC slotted tube set in a granular filter medium and sealed above and below with a bentonite plug. The installations were protected at the surface by a lockable stopcock cover set in concrete. Installation details are given on the relevant borehole log.

Samples for chemical analyses were dispatched daily from site directly to i2 Analytical Laboratories under a Chain of Custody. The remaining samples were brought to this Company's laboratory for testing and storage.

3.2 Logging

The logging of soils and rocks was carried out by an Engineering Geologist in general accordance with BS5930:2015. A key to the exploratory hole logs is presented in Appendix A.

Detailed descriptions of the core and samples are given in the borehole logs, Appendix A, along with details of sampling, in situ testing, groundwater ingress, installations and relevant comments on drilling techniques.

Prior to logging, photographs of the core were taken and are presented separately.

3.3 Laboratory Testing

A schedule of laboratory tests was prepared by the Consultant, the following tests being carried out in accordance with BS1377:1990, unless stated otherwise. The number in brackets refers to the test number given in that standard. The results are presented in Appendix B.

The natural water content was determined on eleven selected samples in accordance with BS EN ISO 17892-1:2014.

Liquid limit, plastic limit and plasticity index tests [Part 2:4.3, 5.3 and 5.4] were carried out on seven selected samples. An Atterberg line plot has also been presented.

Particle size distributions were determined for two samples by wet sieving [Part 2:9.2].

The BRE SD1 (2005) suite of tests was carried out on four samples by Chemtest Laboratories using in-house methods.

Two selected samples were subsampled to provide specimens which had their permeability determined in the triaxial cell [Part 6:6]. The specimens were of nominal sizes of 100mm in diameter by 100mm in height. The specimens were installed in the cell and were saturated by increments of cell pressure and back pressure applied alternatively. The specimen was then consolidated to the required effective stress and then subjected to a pressure difference to cause water to flow downward through the specimen. The permeability was determined once steady state conditions were achieved, i.e. the flow of water into the specimen equals the flow of water out.

Point load index tests were carried out on four selected lengths of core in accordance with I.S.R.M (2007).

Selected samples were dispatched to i2 Analytical Laboratories, where chemical analyses were carried out to in-house methods for a suite of contaminants. The results are presented in Appendix C.

GEOTECHNICAL ENGINEERING LIMITED

4. REFERENCES

British Standards Institution (2015): Code of practice for ground investigations. BS 5930:2015.

British Standards Institution (1990): Methods of tests for soils for civil engineering purposes. BS 1377 Parts 1-9.

British Standards Institution (2014): Geotechnical investigation and testing – Laboratory testing of soil. Part 1: Determination of water content. BS EN ISO 17892-1:2014.

British Standards Institution (2012): Geotechnical investigation and testing. Field testing. Standard penetration test. BS EN ISO 22476-3:2005+A1:2011.

Building Research Establishment (2005): Concrete in aggressive ground. BRE Special Digest 1. Third Edition.

International Society for Rock Mechanics (2007). The complete ISRM suggested methods for rock characterization, testing and monitoring: 1974-2006, edited by R Ulusay & J A Hudson. Ankara, Turkey: Turkish National Group of the International Society for Rock Mechanics.

Key

Approximate Borehole Location

N

Geotechnical Engineering Limited

SITE PLAN

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

SCALE NOT TO SCALE

CONTRACT	FIGURE
32071	1

APPENDIX A

FIELDWORK DATA

Geotechnical Engineering Limited

KEY TO EXPLORATORY HOLE LOGS

Sample type

D	Small disturbed	U	Undisturbed	X/L	Dynamic	D*/ES	Environmental - soil	Cs	Core subsample (prepared)
B	Bulk disturbed	UT	Undisturbed thin wall	C	Core	EW	Environmental - water	Xs/Ls	Dynamic subsample (prepared)
LB	Large bulk disturbed	P	Piston	W	Water				

Test type

S SPT - Split spoon sampler followed by uncorrected SPT 'N' Value
C SPT - Solid cone followed by uncorrected SPT 'N' Value
(*250 - Where full test drive not completed, linearly extrapolated 'N' value reported, ** - Denotes no effective penetration)
H Hand vane - direct reading in kPa - not corrected for BS1377 (1990). Re* denotes refusal
M Mackintosh probe - number of blows to achieve 100mm penetration
PP Pocket penetrometer - direct reading in kg/sq.cm
Vo Headspace vapour reading, uncorrected peak values in ppm, using a PID (calibrated with Isobutylene, using a 10.6eV bulb)

Sample/core range/I_f

Dynamic sample

Undisturbed sample - open drive including thin wall. Symbol length reflects recovery

x x = Total Core Recovery (TCR) as percentage of core run

y y = Solid Core Recovery (SCR) as percentage of core run. Assessment of core is based on full diameter.

z z = Rock Quality Designation (RQD). The amount of solid core greater than 100mm expressed as percentage of core run.

Where SPT has been carried out at beginning of core run, disturbed section of core excluded from SCR and RQD assessment.

I_f - fracture spacing - the modal fracture spacing (mm) over the indicated length of core. Where spacing varies signficantly, the minimum, mode and maximum values are given. NI = non-intact core NA = not applicable

Instrumentation

Porous tip | Perforated standpipe | Granular response zone | Bentonite seal | Cement/ bentonite grout | Soil Backfill | Concrete

Stratum boundaries

Estimated boundary

Grading boundary

Logging

The logging of soils and rocks has been carried out in general accordance with BS 5930:2015.

Chalk is logged in general accordance with Lord et al (2002) CIRIA C574. Where possible, dynamic samples in chalk have been logged in accordance with CIRIA C574; descriptions and gradings (if presented) should be treated with caution given the potential for sample disturbance.

For rocks the term fracture has been used to identify a mechanical break within the core. Where possible incipient and drilling induced fractures have been excluded from the assessment of fracture state. Where doubt exists, a note has been made in the descriptions. All fractures are considered to be continuous unless otherwise reported.

Made Ground is readily identifiable when, within the material make up, man made constituents are evident. Where Made Ground appears to be reworked natural material the differentiation between in situ natural deposits and Made Ground is much more difficult to ascertain. The interpretation of Made Ground within the logs should therefore be treated with caution.

The descriptors "topsoil" and "tarmacadam" are used as generic terms and do not imply conformation to any particular standard or composition.

Rootlets are defined as being less than 2mm in diameter, roots are defined as in excess of 2mm diameter.

General Comments

The process of drilling and sampling will inevitably lead to disturbance, mixing or loss of material in some soil and rocks.

Indicated water levels are those recorded during the process of drilling or excavating exploratory holes and may not represent standing water levels.

All depths are measured along the axis of the borehole and are related to ground level at the point of entry. All inclinations are measured normal to the axis of the core.

Geotechnical Engineering Limited

BOREHOLE LOG

BH01

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 1 of 3

Start Date 13 June 2016 — Easting 154870 — Scale 1 : 50

End Date 15 June 2016 — Northing 35915 — Ground level 4.20mOD — Depth 21.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
13/06/16 1100hrs	1B	0.20 - 0.40						Soft brown slightly sandy slightly gravelly clayey SILT. Gravel is subangular fine to coarse slate and siltstone. Rare roots (up to 4mm diam) and rootlets. (MADE GROUND)	0.10	4.10	
	2B	0.50 - 0.80							0.50	3.70	
13/06/16 1635hrs Dry	1ES	0.50						Light brown and light grey slightly gravelly silty fine SAND. Gravel is subangular fine to coarse slate and siltstone. (MADE GROUND)	1.00	3.20	
	3B	1.00									
	4D	1.00 - 1.45	Nil	S 33							
14/06/16 0800hrs Dry	5L	1.00 - 2.00						Light greyish brown slightly gravelly silty fine SAND. Gravel is subangular fine to coarse slate and siltstone. (MADE GROUND)			
	2ES	1.00									
	3ES	1.50									
	6D	2.00 - 2.45	2.00	S 8				Dense becoming loose light brown and brownish grey very sandy very silty subangular fine and medium slate and siltstone GRAVEL with rare pockets (up to 70mm) of brown clayey silt. (MADE GROUND)			
	7L	2.00 - 2.50									
	8L	2.50 - 3.00									
	4ES	2.50									
	9D	3.00 - 3.45	3.00	S 5					3.05	1.15	
	10L	3.00 - 4.00						Firm black and brown fibrous PEAT.	3.15	1.05	
	5ES	3.50						Soft brown slightly sandy clayey SILT with frequent roots (up to 7mm diam) and rootlets and rare pockets of black organic material (up to 10mm).	3.65	0.55	
	11UT	4.00 - 4.45						Soft grey slightly sandy clayey SILT with rare black pockets of silt (up to 7mm). 3.90 - 4.00m: Sandy silt.	4.00	0.20	
	13L	4.00 - 5.00									
	12D	4.45 - 4.55						Very soft grey slightly peaty silty CLAY.			
	14D	5.00 - 5.45	5.00	S 1					5.00	-0.80	
	15L	5.00 - 6.00						Very soft grey slightly sandy clayey SILT with frequent relict rootlets. 5.30 - 5.40m: Silty fine sand.			
	16UT	6.00 - 6.45									
	17L	6.00 - 7.00							6.75	-2.55	
	18D	7.00 - 7.45	7.00	S 31				Dense grey fine and medium SAND.			
	19L	7.00 - 8.00									
	20D	8.00 - 8.45	8.00	S 4							
								Continued Next Page	{8.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.00m. Dynamic sampled (113mm) 1.00-13.00m. Waterflush rotary core drilled (116mm) 13.00-21.00m.

CASING: 140mm diam to 13.00m.

BACKFILL: On completion, borehole backfilled with bentonite pellets 21.00-10.50m, a slotted standpipe (50mm) was installed to 10.50m, granular response zone 10.50-1.50m, bentonite seal 1.50-0.50m, concrete and stopcock cover 0.50-0.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks
				Groundwater not encountered prior to use of water flush.

AGS

CONTRACT	CHECKED
32071	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

BH01

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 2 of 3

Start Date 13 June 2016 — Easting 154870 — Scale 1 : 50

End Date 15 June 2016 — Northing 35915 — Ground level 4.20mOD — Depth 21.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	21L	8.00 - 9.00							8.20	-4.00	
								Firm brown slightly sandy slightly clayey locally fibrous amorphous PEAT.	9.00	-4.80	
	22UT 23L	9.00 - 9.45 9.00 - 10.00						Soft grey slightly gravelly clayey SILT with frequent relict rootlets. Gravel is subangular fine to coarse quartz and siltstone. 9.60 - 9.80m: Black slightly gravelly silty clay. Gravel is subangular fine and medium quartz and siltstone.	9.80	-5.60	
	24D 25L	10.00 - 10.45 10.00 - 11.00	10.00	S 22				Firm to stiff grey and light brown mottled slightly gravelly silty CLAY with rare pockets (up to 30mm) of black silt. Gravel is angular fine to coarse quartz, slate and mudstone.	10.40	-6.20	
	26D 27L	11.00 - 11.45 11.00 - 12.00	11.00	S 24				Stiff light brown and locally grey slightly gravelly clayey SILT. Gravel is angular and subangular fine to coarse siltstone, slate and quartz. 10.40 - 10.60m: Frequent orange staining. 11.50 - 11.55m: Grey subangular fine to coarse slate gravel locally stained reddish brown.	11.55	-7.35	
	28D 29L	12.00 - 12.45 12.00 - 13.00	12.00	S 38				Dense thinly laminated grey and light brown slightly gravelly SILT. Gravel is subangular fine and medium siltstone and slate. Locally stained orange.	12.50	-8.30	
	30C	13.00 - 13.17 13.00 - 14.00	13.00	C *214	55	NA		Dark brown and grey slightly silty angular and subangular fine to coarse slate and siltstone GRAVEL locally stained orangish brown. 13.00 - 13.50m: Very dense.	13.50	-9.30	
	31C	14.00 - 14.45 14.00 - 15.00	13.00	C 12	70			Stiff thinly laminated light brown and light grey slightly gravelly clayey SILT, Lamination orientated 30-40°. Gravel is subangular fine to coarse slate, mudstone and siltstone.	14.00	-9.80	
14/06/16 1645hrs 4.08m						NI		Medium dense dark grey and orangish brown angular fine to coarse slate, siltstone and quartz GRAVEL. Gravel frequently stained orange	14.80	-10.60	
15/06/16 0700hrs 2.00m	32C	15.00 - 16.50	13.00		65 0 0	NA NI		Stiff thinly laminated light brown and light grey locally black slightly gravelly clayey SILT. Gravel is angular and subangular fine to coarse slate and siltstone. Locally stained orange.	15.20	-11.00	
						NA		Extremely weak highly fractured black frequently mottled white SILTSTONE. Fractures are randomly orientated locally 70° extremely closely spaced undulating rough, 70° fractures frequent infill with iron pyrite (up to 3mm).	15.70	-11.50	
								Thinly laminated light grey and black slightly sandy SILT. Laminae orientated 20°.	16.60	-12.40	
	33C	16.50 - 18.00	13.00		87 13 0	NI NI 90		Extremely weak highly fractured thinly laminated grey and reddish brown SLATE with extremely closely spaced thinly bedded siltstone. Fractures are randomly orientated extremely closely spaced undulating rough.	16.80	-12.60	
								Weak highly fractured grey locally light brown SLATE locally disintegrated to clayey silt. Fractures are randomly orientated extremely closely to closely spaced undulating rough stained reddish brown.			
								Continued Next Page	{18.00}		

water strike (m) casing (m) rose to (m) time to rise (m) remarks

Groundwater not encountered prior to use of water flush.

AGS

CONTRACT 32071

CHECKED CT

Geotechnical Engineering Limited

BOREHOLE LOG

BH01

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 3 of 3

Start Date 13 June 2016 — Easting 154870 — Scale 1 : 50

End Date 15 June 2016 — Northing 35915 — Ground level 4.20mOD — Depth 21.00 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	34C	18.00 - 19.50	13.00		81			17.80 - 18.00m: Fracture 70° undulating rough.			
						NA		Very stiff tending to locally extremely weak thinly laminated light brown and light grey slightly gravelly SILT, laminae orientated 60-70°. Gravel is subangular fine to coarse slate and mudstone. Frequent quartz veins in slate (up to 40mm thick).	18.40	-14.20	
	35C	19.50 - 21.00	13.00		80			20.00 - 20.30m: Laminae are subvertical.			
15/06/16 1025hrs 3.95m								20.55 - 20.60m: Fissure 40° undulating rough. 20.60 - 21.00m: Laminae are subvertical. 20.90 - 21.00m: Frequent orange staining.	21.00	-16.80	
								Borehole completed at 21.00m.	{28.00}		

water strike (m) casing (m) rose to (m) time to rise (m) remarks

Groundwater not encountered prior to use of water flush.

AGS

CONTRACT **32071**

CHECKED **CT**

Geotechnical Engineering Limited

BOREHOLE LOG

BH02

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 1 of 3

Start Date 15 June 2016 — Easting 154872 — Scale 1 : 50

End Date 17 June 2016 — Northing 35872 — Ground level 4.90mOD — Depth 17.20 m

progress date/time water depth	sample no & type	depth (m) from	depth (m) to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
15/06/16 1230hrs	1B	0.10	0.40						Moss over light grey slightly clayey gravelly fine to coarse SAND. Gravel is subangular fine to coarse slate, mudstone and siltstone. (MADE GROUND) 0.20m: Geotextile (up to 2mm).	0.20	4.70	
	2B	0.50	0.70									
	1ES	0.50										
	3B	1.00	1.20						Light greyish brown slightly clayey gravelly fine to coarse SAND. Gravel is subangular fine to coarse slate, mudstone and siltstone. (MADE GROUND) 0.65m: Geogrid (up to 2mm). 0.70 - 0.80m: Crystalline cobbles.	0.80	4.10	
	2ES	1.00										
	4D	1.20	1.65	Nil	S 10							
	5L	1.20	2.20							1.40	3.50	
	3ES	1.50							Light greyish brown slightly clayey gravelly fine to coarse SAND. Gravel is subangular fine to coarse slate, mudstone, siltstone, clinker, rare quartz and rare brick. (MADE GROUND)			
	6D	2.20	2.65	Nil	S 5							
	7L	2.20	2.50						Soft brown slightly gravelly CLAY. Gravel is subangular fine to coarse slate, siltstone, quartz and rare brick. Rare rootlets. (MADE GROUND)			
	8L	2.50	3.20									
	4ES	2.50								2.80	2.10	
	UT	3.20		Nil					Soft grey gravelly CLAY. Gravel is subangular fine to coarse mudstone and slate. 2.85 - 2.95m: Firm dark brown amorphous peat. 3.20 - 3.25m: Firm dark brown amorphous peat.			
	9L	3.20	4.20	3.20						3.50	1.40	
	5ES	3.50							Brown and grey slightly clayey angular fine to coarse slate and mudstone GRAVEL.	3.90	1.00	
	10D	4.20	4.87	4.20	S 2				Very soft thinly laminated grey slightly sandy clayey SILT with abundant laminations of brown and black partly decomposed organic material.			
	11L	4.20	5.20							4.70	0.20	
									Soft grey slightly sandy clayey SILT with rare relict rootlets.			
	12UT	5.20	5.65	5.20								
	13L	5.20	6.20							5.70	-0.80	
15/06/16 1755hrs 3.58m									Loose grey very silty fine and medium SAND with rare shell fragments (up to 40mm).			
	14D	6.20	6.65	6.20	S 7							
16/06/16 0700hrs 2.52m	15L	6.20	7.20							6.60	-1.70	
									Grey tending to brownish grey silty fine SAND with frequent partly decomposed rootlets.			
	16D	7.20	7.65	7.20	S 3							
	17L	7.20	8.20							7.30	-2.40	
									Spongy brown amorphous PEAT.			
										8.00	-3.10	
									Continued Next Page	{8.00}		

EQUIPMENT: Geotechnical Pioneer rig.

METHOD: Hand dug inspection pit 0.00-1.20m. Dynamic sampled (128mm) 1.20-2.50m, (113mm) 2.50-11.20m. Waterflush rotary core drilled (116mm) 11.20-17.20m.

CASING: 140mm diam to 14.20m.

BACKFILL: On 17/06/2016, borehole backfilled with bentonite pellets 17.20-9.00m, a slotted standpipe (50mm) was installed to 9.00m, granular response zone 9.00-1.50m, bentonite seal 1.50-0.50m, concrete and stopcock cover 0.50-0.00m.

EXPLORATORY HOLE LOGS SHOULD BE READ IN CONJUNCTION WITH KEY SHEETS

water strike (m)	casing (m)	rose to (m)	time to rise (min)	remarks
				Groundwater not encountered prior to use of water flush.

AGS

CONTRACT	CHECKED
32071	**CT**

Geotechnical Engineering Limited

BOREHOLE LOG

BH02

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 2 of 3

Start Date 15 June 2016 — Easting 154872 — Scale 1 : 50

End Date 17 June 2016 — Northing 35872 — Ground level 4.90mOD — Depth 17.20 m

progress date/time water depth	sample no & type	depth (m) from to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
	18L	8.20 - 8.65 8.20 - 9.20	8.20	S 7				Firm light brownish grey and grey slightly gravelly clayey SILT. Gravel is subangular fine to coarse mudstone and quartz. 8.10 - 8.20m: Quartz cobble.	8.50	-3.60	
	19D 20L	9.20 - 9.65 9.20 - 10.20	9.20	S 9				Soft light brown slighty gravelly clayey SILT with frequent pockets (up to 5mm) of black silt. Gravel is subangular fine and medium siltstone.	9.30	-4.40	
	21D 22L	10.20 - 10.65 10.20 - 11.20	10.20	S 24				Firm light brown and grey slightly gravelly clayey SILT with abundant orange staining and orange and light brown randomly orientated veins (up to 2mm). Gravel is subangular fine and medium slate and siltstone.	10.50	-5.60	
	23C	11.20 - 11.43 11.20 - 12.20	11.20	C*188	90 13 0	NA NI 30 70		Stiff thinly laminated light brown and grey slightly gravelly clayey SILT with abundant orange staining and orange and light brown randomly orientated veins (up to 2mm). Gravel is subangular fine and medium slate and siltstone.	11.40	-6.50	
	24C	12.20 - 13.20			95 1 0			Extremely weak and very weak highly fractured grey frequently stained orange and reddish brown SLATE locally disintegrated to slightly gravelly clayey silt and with rare quartz veins (up to 20mm). Gravel is angular and subangular fine to coarse slate. Fractures are randomly orientated extremely closely to closely spaced stepped and undulating rough. 12.80 - 13.00m: 40°-60° fracture.			
	25C	13.20 - 14.50			88 12 8			13.10 - 13.20m: Grey and light brown slightly gravelly clayey silt. Gravel is angular and subangular fine to coarse slate.	13.60	-8.70	
						NA		Very stiff thinly laminated light orangish brown and light brown gravelly clayey SILT. Gravel is angular and subangular fine to coarse slate.	13.80	-8.90	
	26C	14.50 - 15.70			71 14 0	NI NI 40 110		Weak highly fractured grey SILTSTONE. Fractures are randomly orientated locally 20-30° extremely closely to closely spaced undulating rough intersecting 60-70° extremely closely to very closely spaced stepped smooth frequently staining orangish brown. 14.40 - 14.50m: Grey and light brown slightly gravelly clayey silt. Gravel is angular and subangular fine to coarse slate.	14.50 14.90	-9.60 -10.00	
	27C	15.70 - 17.20			86 55 25	NI NI 60 180		Very weak highly fractured grey SLATE with frequent quartz veins (up to 40mm). Fractures are randomly orientated locally 20-30° extremely closely and very closely spaced undulating and stepped rough and smooth. Very weak grey SILTSTONE with frequent quartz veins (up to 50mm). Fractures are randomly orientated extremely closely to closely spaced undulating rough fracture frequently stained orange and reddish brown.	15.70 16.20	-10.80 -11.30	
16/06/16 1800hrs 1.62m						NI 50 130		Very weak highly fractured grey SLATE with frequent quartz veins (up to 40mm). Fractures are randomly orientated locally 20-30° extremely closely and very closely spaced undulating and stepped rough and smooth.	16.70 17.20	-11.80 -12.30	
17/06/16 0700hrs 3.20m								Weak grey SILTSTONE with frequent quartz veins (up to 40mm). Fractures are subhorizontal to 30° and 45-70° very closely and closely spaced undulating rough,			
								Continued Next Page	{18.00}		

water strike (m) casing (m) rose to (m) time to rise (m) remarks

Groundwater not encountered prior to use of water flush.

AGS

CONTRACT 32071

CHECKED CT

Geotechnical Engineering Limited

BOREHOLE LOG

BH02

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS — Sheet 3 of 3

Start Date 15 June 2016 — Easting 154872 — Scale 1 : 50

End Date 17 June 2016 — Northing 35872 — Ground level 4.90mOD — Depth 17.20 m

progress date/time water depth	sample no & type	depth (m) from	depth (m) to	casing depth (m)	test type & value	samp. /core range	I_f	instru -ment	description	depth (m)	reduced level (m)	legend
									frequently stained orange.			
									Extremely weak and very weak thinly laminated grey and dark grey SLATE with rare quartz veins (up to 20mm). Fractures are randomly orientated locally 20-30° extremely closely to closely spaced undulating planar rough and smooth.			
									Borehole completed at 17.20m.	{28.00}		

water strike (m) casing (m) rose to (m) time to rise (m) remarks

Groundwater not encountered prior to use of water flush.

AGS

CONTRACT 32071

CHECKED CT

Geotechnical Engineering Limited

STANDARD PENETRATION TEST

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

borehole no.	borehole depth (m)	bottom depth (m)	casing depth (m)	water level (m)	seating drive blows	seating drive pen (mm)	test drive blows	test drive pen (mm)	test type	N	energy ratio (%)
BH01	1.00	1.45	Nil	Dry	4 7	75 75	9 10 7 7	75 75 75 75	S	33	70
BH01	2.00	2.45	2.00	0.32	1 3	75 75	2 2 2 2	75 75 75 75	S	8	70
BH01	3.00	3.45	3.00	2.25	1 0	75 75	1 1 1 2	75 75 75 75	S	5	70
BH01	5.00	5.45	5.00	3.01	1 0	75 75	0 0 0 1	75 75 75 75	S	1	70
BH01	7.00	7.45	7.00	2.20	1 4	75 75	5 8 9 9	75 75 75 75	S	31	70
BH01	8.00	8.45	8.00	2.65	1 3	75 75	1 1 1 1	75 75 75 75	S	4	70
BH01	10.00	10.45	10.00	3.21	2 6	75 75	5 5 6 6	75 75 75 75	S	22	70
BH01	11.00	11.45	11.00	0.85	2 6	75 75	5 6 6 7	75 75 75 75	S	24	70
BH01	12.00	12.45	12.00	1.28	4 8	75 75	8 8 11 11	75 75 75 75	S	38	70
BH01	13.00	13.17	13.00	2.20	14 11	75 20	50	70	C	214	70
BH01	14.00	14.45	13.00	1.53	2 2	75 75	3 3 3 3	75 75 75 75	C	12	70
BH02	1.20	1.65	Nil	Dry	2 3	75 75	3 2 2 3	75 75 75 75	S	10	70
BH02	2.20	2.65	Nil	Dry	1 2	75 75	1 1 2 1	75 75 75 75	S	5	70
BH02	4.20	4.65	4.20	1.65	0 0	75 75	0 0 0 2	75 75 75 75	S	2	70
BH02	6.20	6.65	6.20	2.12	1 0	75 75	1 2 2 2	75 75 75 75	S	7	70
BH02	7.20	7.65	7.20	3.25	0 0	75 75	0 1 1 1	75 75 75 75	S	3	70
BH02	8.20	8.65	8.20	2.20	1	75 75	1 2 2 2	75 75 75 75	S	7	70
BH02	9.20	9.65	9.20	2.86	3 3	75 75	2 2 3 2	75 75 75 75	S	9	70
BH02	10.20	10.65	10.20	2.08	6 8	75 75	8 5 5 6	75 75 75 75	S	24	70
BH02	11.20	11.43	11.20	3.58	5 18	75 75	40 10	75 5	C	188	70

notes:

1. Test carried out in general accordance with BS EN ISO 22476-3:2005 + A1:2011
2. N values have not been subjected to any correction.
3. Test carried out using split spoon S, solid cone C.
4. Where full test drive not completed, linearly extrapolated N value reported.
5. <1 Denotes hammer self weight penetration (sank under own weight).
6. ** Denotes no effective penetration.

CONTRACT	CHECKED
32071	**CT**

APPENDIX B

LABORATORY TESTING

2718

GEOTECHNICAL ENGINEERING LIMITED

Version No.	2
For the attention of Chris Yates/Ben Corrigan	Page No. 1 of 11
	Date of Issue 28/07/2016

TEST REPORT

PROJECT/SITE	Hayle Sewage Treatment Works	Samples received	23/06/2016
GEL REPORT NUMBER	32071	Schedule received	23/06/2016
Your ref/PO:	0	Testing commenced	27/06/2016
Test report refers to	Schedule 1	Status	Final

SUMMARY OF RESULTS ATTACHED

TEST METHOD & DESCRIPTION	QUANTITY	ACCREDITED TEST
BS EN ISO 17892-1: 2014:5. Water Content	11	YES
BS1377: Part 2: 1990:4.2-4.4&5.2-5.4, Liquid & Plastic Limits	7	YES
BS1377: Part 2: 1990:9.2, Particle Size Distribution - Wet Sieve	2	YES
BS1377: Part 6: 1990:6, Constant Head Permeability	2	NO
ISRM: Suggested Methods: 2007 Edition: Point Load Strength Test	4	NO
BRE SD1 Suite (subcontracted)	4	YES/NO

Remarks

Approved Signatories:

S Robinson (Client Manager) C Andrew (Client Manager)

W Jones (Technical Support) J Hanson (Director) N Parry (Director)

Geotechnical Engineering Ltd
Centurion House
Olympus Park, Quedgeley
Gloucester GL2 4NF

Registered number: 00700739
VAT Number: 682 5857 89

www.geoeng.co.uk
geotech@geoeng.co.uk
TEL: 01452 527743
Fax: 01452 729314

Payments: Geotechnical Engineering Limited
Sort code: 30-15-99 **Bank account**: 00072116

Geotechnical Engineering Limited

LIQUID AND PLASTIC LIMITS

BS.1377 : Part 2 : 1990 : 4 and 5

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

borehole /trial pit no.	sample		specimen depth (m)	natural water content (%)	specimen preparation and test method	fraction >0.425 mm (%)	liquid limit (%)	plastic limit (%)	plasticity index (%)	description and remarks
	no./type	depth (m)								
BH01	9D	3.00	3.00	38.1	BYE	23	47	30	17	Brown slightly sandy slightly gravelly SILT
BH01	15L	5.00	5.70	46.6	BXE	1	39	31	8	Grey slightly sandy SILT with rare shell fragments
BH01	17L	6.00	6.70	33.6	E					Grey slightly sandy SILT
BH01	23L	9.00	9.70	18.1	E					Yellowish brown mottled grey slightly sandy slightly gravelly SILT
BH01	27L	11.00	11.70	18.6	BXE	9	43	31	12	Yellowish brown slightly gravelly slightly sandy SILT
BH01	29L	12.00	12.35	14.3	BXE	61	39	27	12	Yellowish brown slightly sandy gravelly SILT
BH02	11L	4.20	4.50	64.9	BXE	0	54	27	27	Brownish grey slightly sandy CLAY with organic material
BH02	13L	5.20	5.50	44.4	E					Grey slightly sandy sandy SILT
BH02	18L	8.20	8.50	25.0	E					Greenish brown slightly sandy slightly gravelly SILT
BH02	20L	9.20	9.75	23.3	BXE	22	45	34	11	Orangish brown slightly sandy slightly gravelly SILT
BH02	22L	10.20	10.50	22.1	BXE	35	41	31	10	Orangish brown slightly sandy slightly gravelly SILT

general remarks:
natural water content determined in accordance with BS EN ISO 17892 - 1 : 2014
NP denotes non-plastic
# denotes sample tested is smaller than that which is recommended in accordance with BS1377 or BS EN ISO 17892

specimen preparation:
A - as received
B - washed on 0.425mm sieve
C - air dried
D - oven dried (60°C)
E - oven dried (105°C)
F - not known

test method:
X - cone penetrometer (test 4.3)
Y - one point cone penetrometer (test 4.4)
Z - Casagrande apparatus (test 4.5)

CONTRACT **32071**

CHECKED **CA**

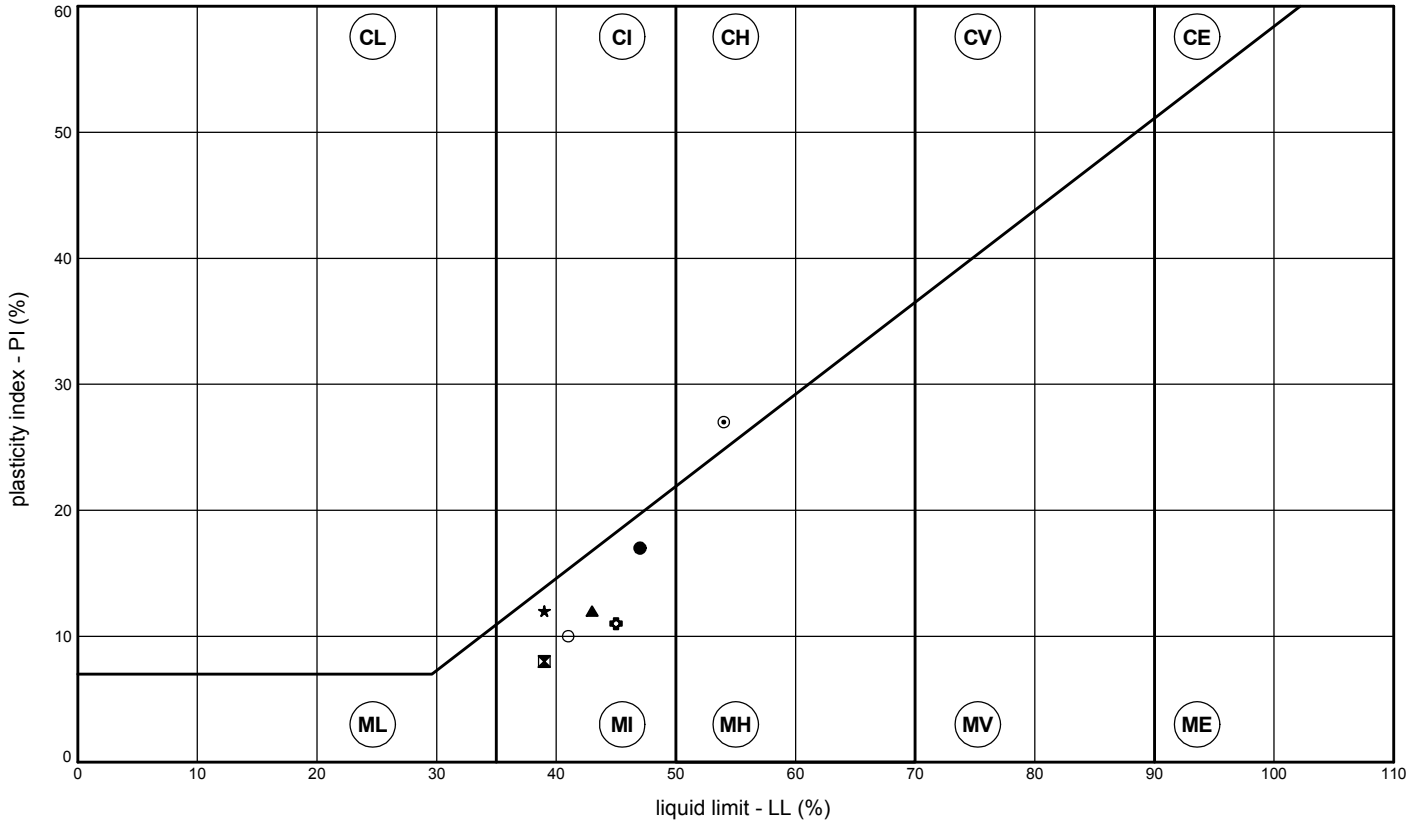
Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester. GL2 4NF. Tel. 01452 527743 32071_HAYLE.GPJ 22/07/2016 14:32:50

Geotechnical Engineering Limited

ATTERBERG LINE PLOT

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS



	BH/TP No.	depth (m)	LL	PL	PI	remarks
●	BH01	3.00	47	30	17	
⊠	BH01	5.70	39	31	8	
▲	BH01	11.70	43	31	12	
★	BH01	12.35	39	27	12	
⊙	BH02	4.50	54	27	27	
✿	BH02	9.75	45	34	11	
○	BH02	10.50	41	31	10	

CONTRACT	CHECKED
32071	**CA**

Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester. GL2 4NF. Tel. 01452 527743 32071_HAYLE.GPJ 22/07/2016 14:33:44

Geotechnical Engineering Limited

PARTICLE SIZE DISTRIBUTION

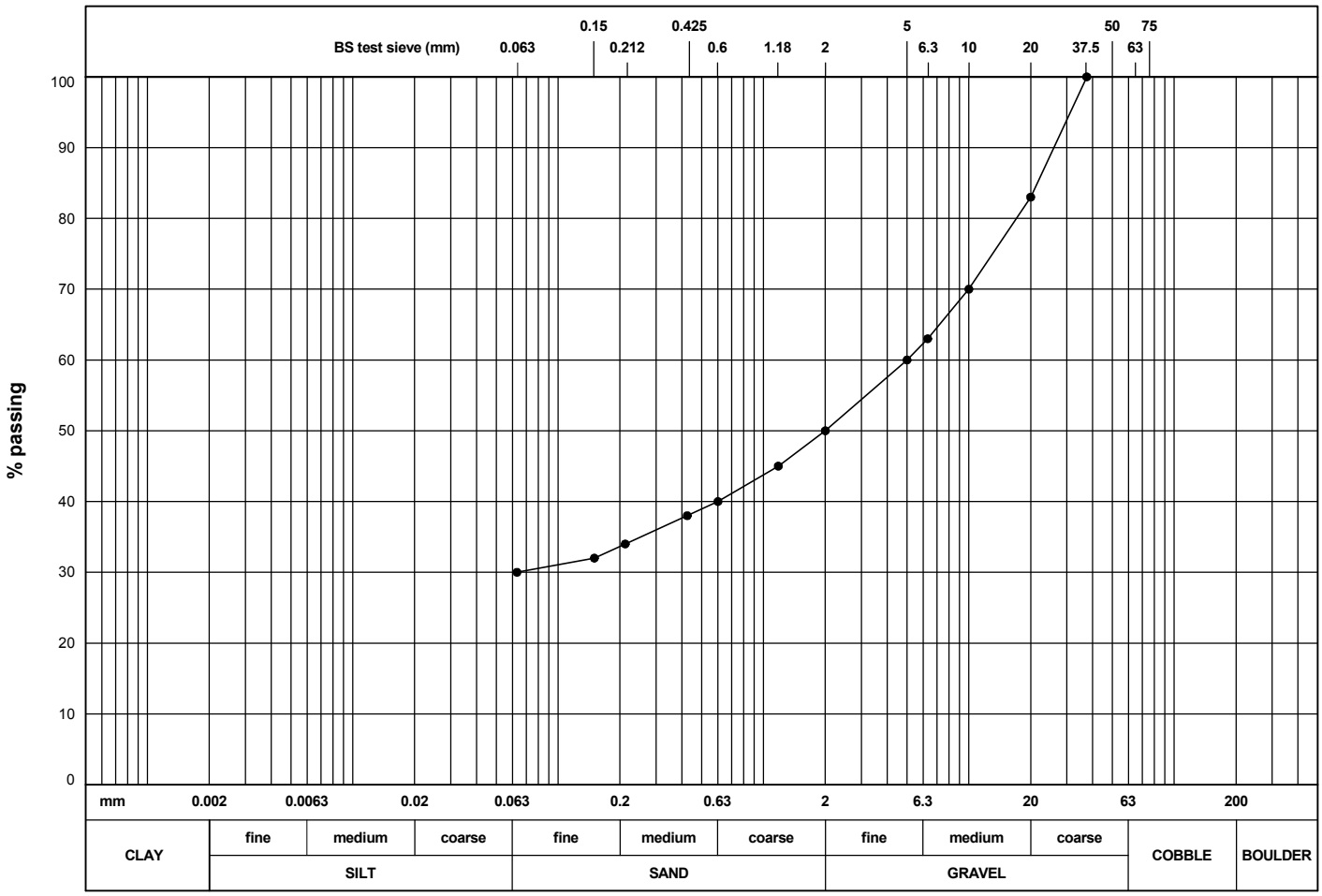
BS.1377 : Part 2 : 1990 : 9

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

DESCRIPTION Brown mottled grey very sandy very silty GRAVEL

BH/TP No.	BH01
SAMPLE No./TYPE	5L
SAMPLE DEPTH (m)	1.00
SPECIMEN DEPTH (m)	1.50



soil type	% fraction
CLAY	
SILT	
SILT & CLAY	30
SAND	20
GRAVEL	50
COBBLE & BOULDER	0
test method(s)	9.2#

BS test sieve (mm)	% passing	BS test sieve (mm)	% passing	particle size (μm)	% finer
150		5	60	20	
75		2	50	6	
63		1.18	45	2	
50		0.6	40		
37.5	100	0.425	38		
20	83	0.212	34		
10	70	0.15	32		
6.3	63	0.063	30		

test method:
9.2 - wet sieving
9.3 - dry sieving
9.4 - sedimentation by pipette
9.5 - sedimentation by hydrometer

remarks:
# denotes sample tested is smaller than that which is recommended in accordance with BS1377

CONTRACT **32071**

CHECKED **CA**

Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester, GL2 4NF. Tel. 01452 527743 32071_HAYLE.GPJ 22/07/2016 14:34:08

Geotechnical Engineering Limited

PARTICLE SIZE DISTRIBUTION

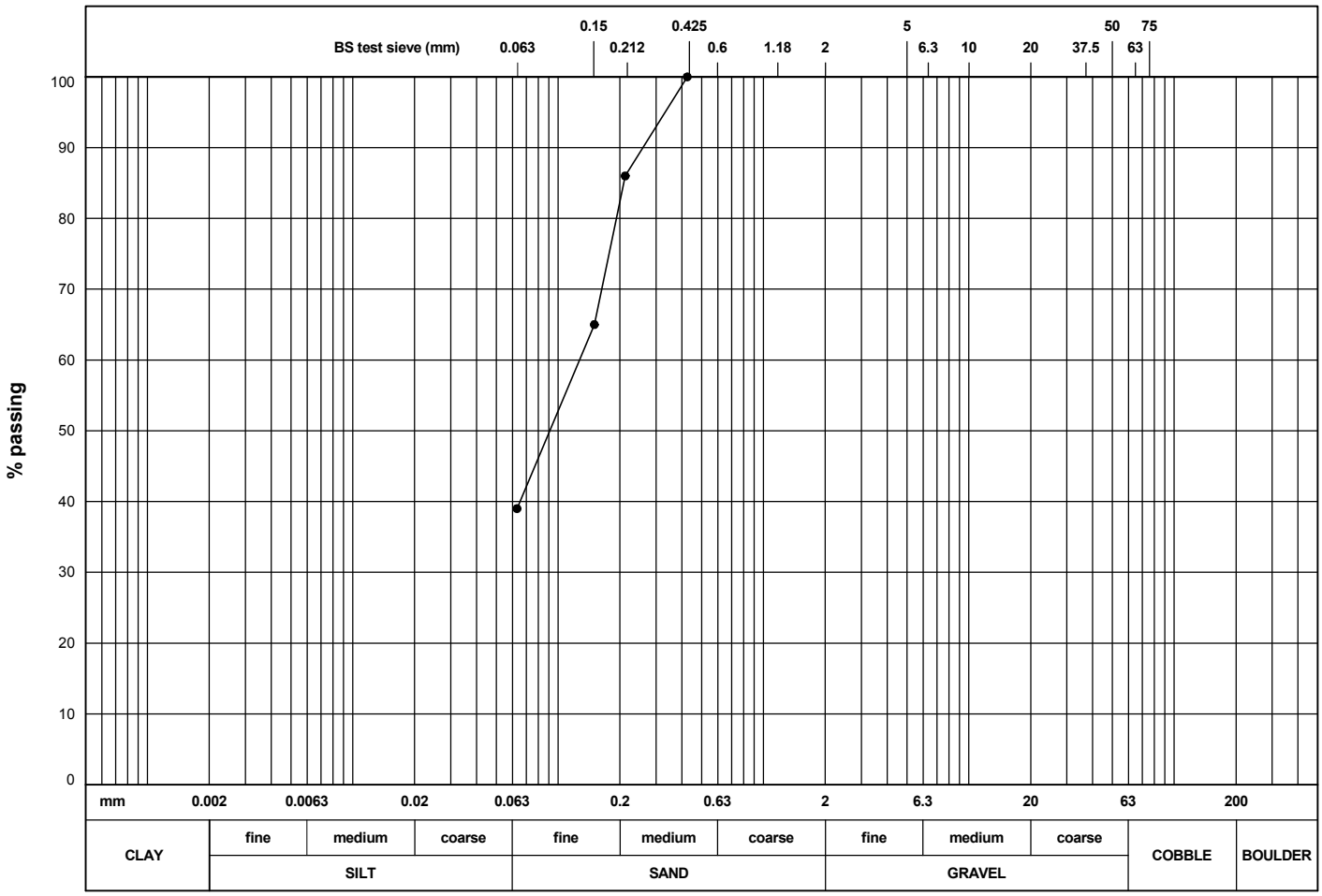
BS.1377 : Part 2 : 1990 : 9

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

DESCRIPTION Greyish brown sandy SILT

BH/TP No.	BH02
SAMPLE No./TYPE	15L
SAMPLE DEPTH (m)	6.20
SPECIMEN DEPTH (m)	6.50



soil type	% fraction
CLAY	
SILT	
SILT & CLAY	39
SAND	61
GRAVEL	0
COBBLE & BOULDER	0
test method(s)	9.2

test method:
9.2 - wet sieving
9.3 - dry sieving
9.4 - sedimentation by pipette
9.5 - sedimentation by hydrometer

BS test sieve (mm)	% passing
150	
75	
63	
50	
37.5	
20	
10	
6.3	

BS test sieve (mm)	% passing
5	
2	
1.18	
0.6	
0.425	100
0.212	86
0.15	65
0.063	39

particle size (μm)	% finer
20	
6	
2	

remarks:
# denotes sample tested is smaller than that which is recommended in accordance with BS1377

CONTRACT	CHECKED
32071	**CA**

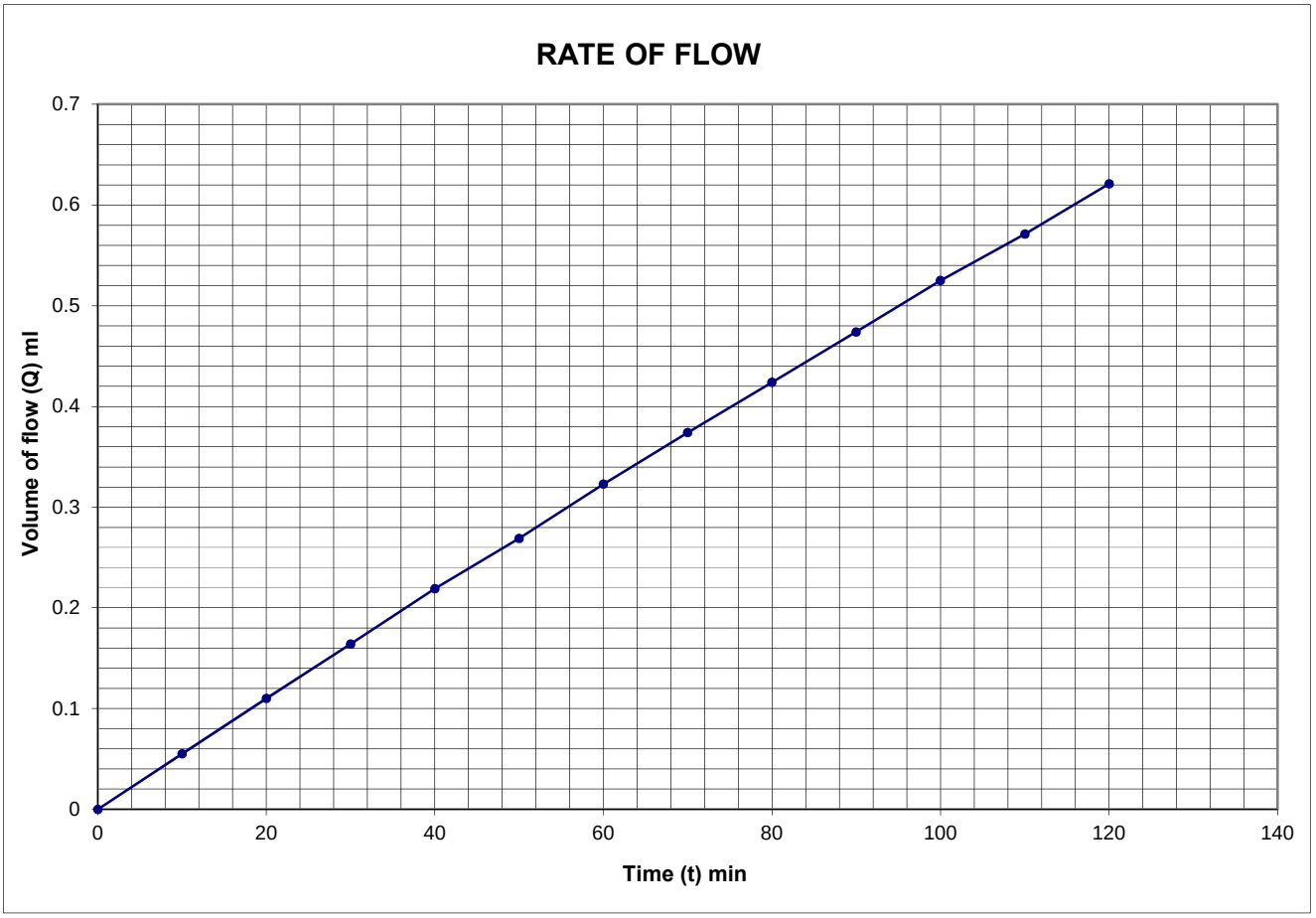
Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester. GL2 4NF. Tel. 01452 527743 32071_HAYLE.GPJ 22/07/2016 14:34:08

Geotechnical Engineering Limited

CONSTANT HEAD PERMEABILITY TEST

BS1377 : Part 6 : 1990 : Cl 6 (Triaxial Cell) and "Manual of Soil Laboratory Testing", Volume 3, K.H. Head & R.J. Epps

CLIENT	SOUTH WEST WATER	BH/TP No.	BH01
SITE	HAYLE SEWAGE TREATMENT WORKS	SAMPLE No./TYPE	11UT
		SAMPLE DEPTH (m)	4.00-4.45
DESCRIPTION	Brownish grey, slightly sandy, organic silty CLAY	SPECIMEN DEPTH (m)	4.10-4.20



						Initial	Final
Cell pressure	(kPa)	380		Length	(mm)	108	104
Inlet pressure (top)	(kPa)	350		Diameter	(mm)	103	100
Outlet pressure (base)	(kPa)	330		Moisture content	(%)	66.4	54.9
Pressure difference	(kPa)	20		Bulk density	(Mg/m^3)	1.59	1.62
Mean effective stress	(kPa)	40		Dry density	(Mg/m^3)	0.95	1.04

From graph, mean flow rate (Q) (ml/min) 0.0052

Coefficient of Permeability k (m/s) **5.6E-10**

remarks	CONTRACT	CHECKED
	32071	NP
(Saturation by cell pressure and back pressure increments)		

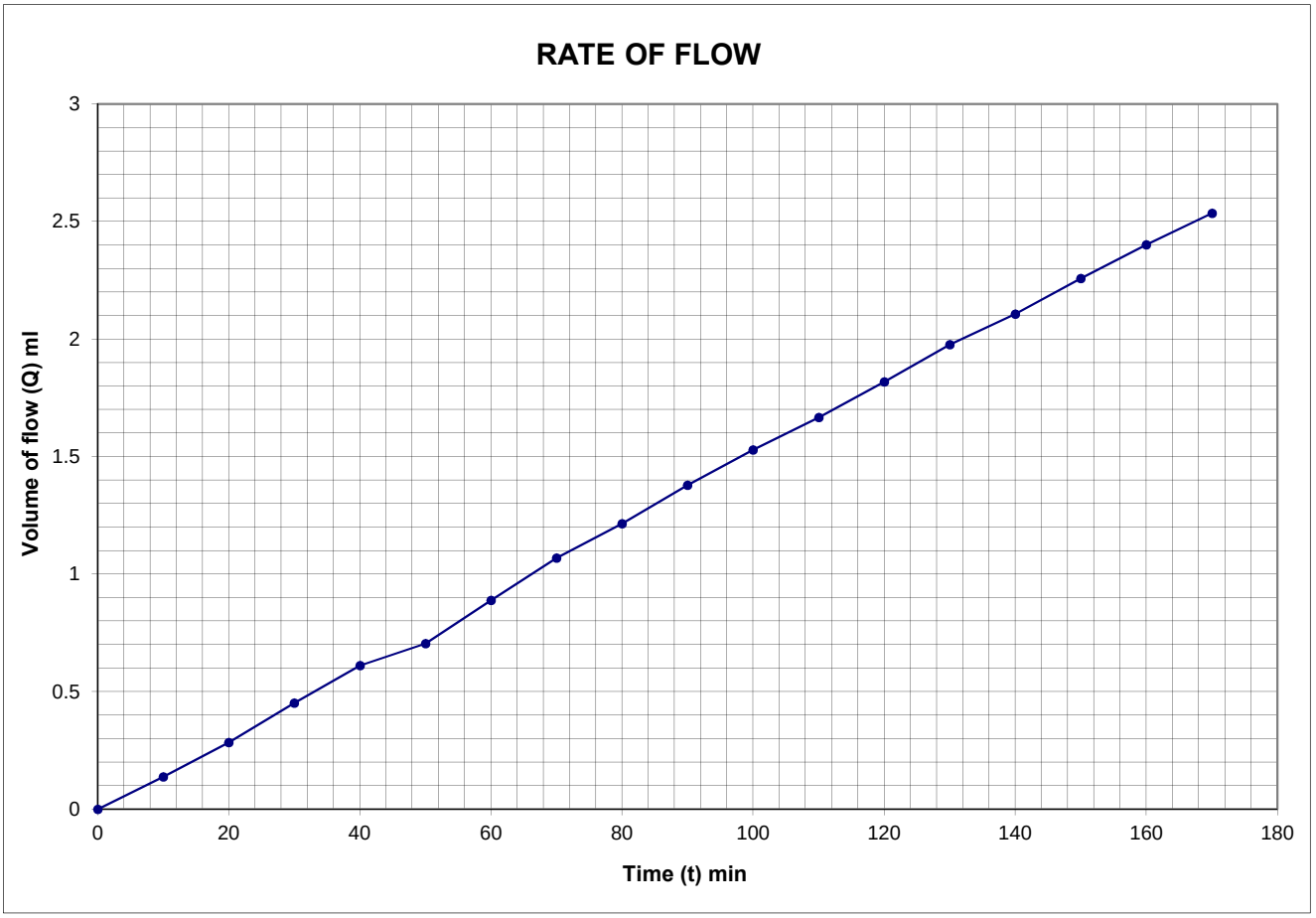
Geotechnical Engineering Ltd. Centurion House, Olympus Park, Gloucester, GL2 4NF. Tel - 01452 527743

Geotechnical Engineering Limited

CONSTANT HEAD PERMEABILITY TEST

BS1377 : Part 6 : 1990 : Cl 6 (Triaxial Cell) and "Manual of Soil Laboratory Testing", Volume 3, K.H. Head & R.J. Epps

CLIENT	SOUTH WEST WATER	BH/TP No.	BH02
SITE	HAYLE SEWAGE TREATMENT WORKS	SAMPLE No./TYPE	12UT
		SAMPLE DEPTH (m)	5.20-5.65
DESCRIPTION	Greyish brown slightly sandy clayey SILT	SPECIMEN DEPTH (m)	5.50-5.60



						Initial	Final
Cell pressure	(kPa)	385		Length	(mm)	107	106
Inlet pressure (top)	(kPa)	355		Diameter	(mm)	102	100
Outlet pressure (base)	(kPa)	325		Moisture content	(%)	45.9	39.7
Pressure difference	(kPa)	30		Bulk density	(Mg/m^3)	1.77	1.76
Mean effective stress	(kPa)	45		Dry density	(Mg/m^3)	1.22	1.26

From graph, mean flow rate (Q) (ml/min) 0.0150

Coefficient of Permeability k (m/s) **1.1E-09**

remarks	CONTRACT	CHECKED
	32071	NP
(Saturation by cell pressure and back pressure increments)		

Geotechnical Engineering Ltd. Centurion House, Olympus Park, Gloucester, GL2 4NF. Tel - 01452 527743

Geotechnical Engineering Limited

POINT LOAD STRENGTH TEST RESULTS

I.S.R.M. Suggested Methods 2007 Edition

CLIENT SOUTH WEST WATER

SITE HAYLE SEWAGE TREATMENT WORKS

borehole /trial pit no.	sample depth (m)	test type	test orientation	moisture condition	width W (mm)	length L (mm)	platen sep. D (mm)	failure load P (kN)	equiv. dia. De (mm)	Is (MPa)	size factor F	Is(50) (MPa)	rock type
BH01	17.30	D	Y	P		30	90	5.17	90.00	0.64	1.30	0.83	Dark grey SLATE
BH01	17.30	A	X	P	90		65	5.37	86.30	0.72	1.28	0.92	Dark grey SLATE
BH02	14.30	D	Y	P		70	90	0.32	90.00	0.04	1.30	0.05	Dark grey SILTSTONE
BH02	14.30	A	X	P	90		60	0.39	82.92	0.06	1.26	0.07	Dark grey SILTSTONE
BH02	15.30	I	U	P	90	40	40	0.93	67.70	0.20	1.15	0.23	Dark grey SILTSTONE
BH02	16.40	D	Y	P		90	90	4.96	90.00	0.61	1.30	0.80	Dark grey SILTSTONE
BH02	16.40	A	X	P	90		120	5.14	117.26	0.37	1.47	0.55	Dark grey SILTSTONE

remarks: Tests carried out in accordance with I.S.R.M.(2007): Suggested Methods for Determining Point Load Strength. Int. J. Rock Mech. Min. Sci. and Geotech. Abstr. Vol.22 No. 2.

test type:
D - diametral
A - axial
I - Irregular lump

test orientation relative to discontinuities:
X - perpendicular U - unknown
Y - parallel
Z - oblique

moisture condition:
N - natural moisture content
P - partially air dried
S - soaked

CONTRACT **32071**

CHECKED **CA**

Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester. GL2 4NF. Tel. 01452 527743 32071_HAYLE.GPJ 28/07/2016 10:49:06

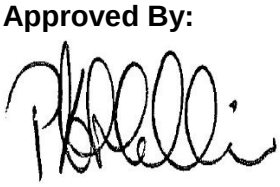
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.co.uk

Final Report

Report No.:	16-15214-1
Initial Date of Issue:	30-Jun-2016
Client	Geotechnical Engineering Ltd
Client Address:	Centurion House Olympus Park Quedgeley Gloucester Gloucestershire GL2 4NF
Contact(s):	Claire Andrew
Project	32071 Hayle STW

Quotation No.:		**Date Received:**	27-Jun-2016
Order No.:		**Date Instructed:**	27-Jun-2016
No. of Samples:	4		
Turnaround (Wkdays):	5	**Results Due:**	01-Jul-2016
Date Approved:	30-Jun-2016		

Approved By:



Details: Phil Hellier, Project Director

Chemtest
The right chemistry to deliver results

Results - Soil

Project: 32071 Hayle STW

Client: Geotechnical Engineering Ltd			**Chemtest Job No.:**		16-15214	16-15214	16-15214	16-15214
Quotation No.:			**Chemtest Sample ID.:**		315446	315447	315448	315449
Order No.:			Client Sample Ref.:		BH01	BH01	BH02	BH02
			Client Sample ID.:		3B	32C	13L	25C
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		1.00	15.00	5.20	13.20
			Date Sampled:		24-Jun-2016	24-Jun-2016	24-Jun-2016	24-Jun-2016
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Moisture	N	2030	%	0.020	9.8	9.3	29	4.3
pH	U	2010		N/A	8.5	8.3	9.0	8.5
Magnesium (Water Soluble)	N	2120	g/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Sulphate (2:1 Water Soluble) as SO4	U	2120	g/l	0.010	0.026	0.011	0.26	< 0.010
Total Sulphur	U	2175	%	0.010	< 0.010	0.021	0.63	< 0.010
Chloride (Water Soluble)	U	2220	g/l	0.010	0.011	< 0.010	0.18	< 0.010
Nitrate (Water Soluble)	N	2220	g/l	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Sulphate (Acid Soluble)	U	2430	%	0.010	0.019	0.017	0.17	< 0.010

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"

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 our Coventry 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

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.co.uk

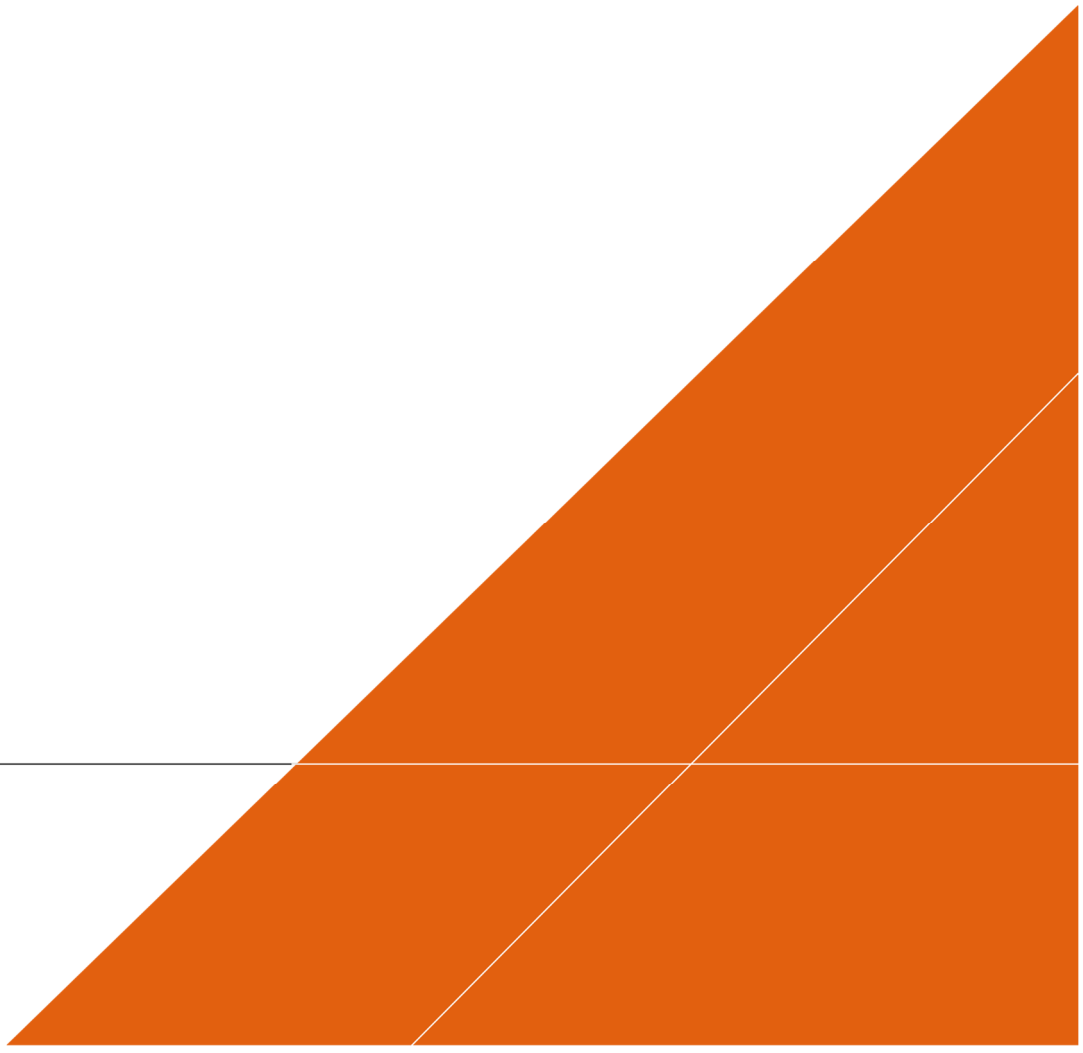
Appendix C – Arcadis GI, 2016

ARCADIS Design & Consultancy for natural and built assets

HAYLE INLET WWTW

Ground Investigation Report

July 2016



Incorporating

EC HARRIS BUILT ASSET CONSULTANCY

Hyder

CONTACTS

GARY WALKER
AFS Technical Director

dd +44 (0) 117 372 1385
df +44 (0) 117 372 1200
m +44 (0) 786 752 1175
e gary.walker@arcadis.com

Arcadis.
5th Floor
The Pithay, All Saints Street
Bristol
BS1 2NL
United Kingdom

Hayle WwTw Inlet SI

Ground Investigation Report

AUTHORISED SIGNATURES

Author	S Carter
Checker	P Welburn
Approver	G Francis
Report No	UA008501-AFS-GLR-G001
Date	July 2016

Version control

Version	Date	Author	Changes
01	July 2016	S Carter	

CONTENTS

IMAGES

TABLES

APPENDICES

APPENDIX A

DRAWINGS

Drawing UA008501-GLR-EHP-0001: Exploratory Hole Location Plan

APPENDIX B

STANDARD PROCEDURES

APPENDIX C

EXPLORATORY HOLE LOGS

APPENDIX D

CERTIFICATION OF FIELD APPARATUS

APPENDIX E

GEOTECHNICAL LABORATORY TEST DATA

APPENDIX F

GEO-ENVIRONMENTAL LABORATORY TEST DATA

1 INTRODUCTION

Arcadis Consulting (UK) Limited (Arcadis) was instructed by South West Water, 'the Client', on 5th May 2016 to undertake a ground investigation at Hayle Waste water Treatment works in St Erth, Hayle, Cornwall. The purpose of the investigation was to confirm the below ground conditions and establish the soil's material properties to enable suitable foundations to be designed.

The scope of the ground investigation was determined by Arcadis Consulting (UK) Ltd.

This ground investigation report provides a factual account of the fieldwork undertaken, the strata encountered, results of *in situ* testing and the subsequent geotechnical and pH laboratory testing undertaken on samples obtained.

1.1 Limitations

This report has been prepared for the Client in accordance with the terms and conditions of appointment. Arcadis cannot accept any responsibility for any use of or reliance on the contents of this report by any third party. The copyright of this document, including the electronic format and any AGS data, shall remain the property of Arcadis.

Arcadis do not accept liability for any use of the information presented in this report unless it is signed by the author, checker and approver and marked as final.

It should be noted that ground conditions between exploratory holes may vary from those identified during this ground investigation; any design should take this into consideration. It should also be noted that groundwater levels may be subject to diurnal, tidal, seasonal, climatic variations and those recorded in this report are solely dependent on the time the ground investigation was carried out and the weather before and during the investigation.

1.2 Proposed Development

The proposed development at the site comprises the refurbishment of the existing facilities within the sewage treatment works and the addition of new equipment, such as the installation of new fine and coarse screens which are used to remove particles during the grit extraction which may cause maintenance issues; the construction of new bypass channel and pipes, and new vortex grit trap tanks. A new grit skip and classifier are also proposed, along with a grit extraction pump and rising main connected to the vortex grit trap tank.

1.3 Existing Information

The following information relating to the site and the ground conditions was made available to Arcadis prior to mobilisation to the site:

a. Ground Investigation Scope and Specification [1]; source Arcadis Consulting (UK) Ltd and South West Water.

2 SITE DETAILS

2.1 Site Location and Description

The site is situated in the village of St Erth approximately 2.3 km southwest of Hayle in West Cornwall, with a NGR of SW 54715 35807. Image 2-1 shows the site location.

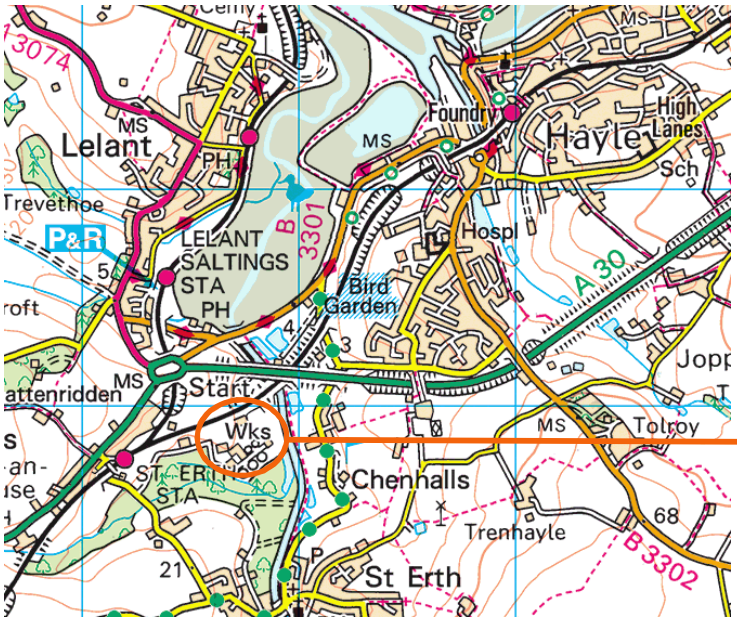


Image 2-1: Site Location

Hayle Wastewater Treatment works (WwTw) is a large working sewage treatment scheme for Penzance and St Ives, operating since early 1995. Two large upgrades of the facility have already taken place, the first in 1995 and the second in 2000. The area is approximately 300 m by 300 m and orientated in a north-westerly direction,

Due to the working conditions of the site a number of access roads are present between the buildings and tanks of the sewage treatment works, therefore the majority of the site is that of hardstanding. Small areas of the site have been landscaped, such as small areas of grassland and trees lining the treatment tanks. The sewage treatment works slopes approximately 4 m from the north to the south.

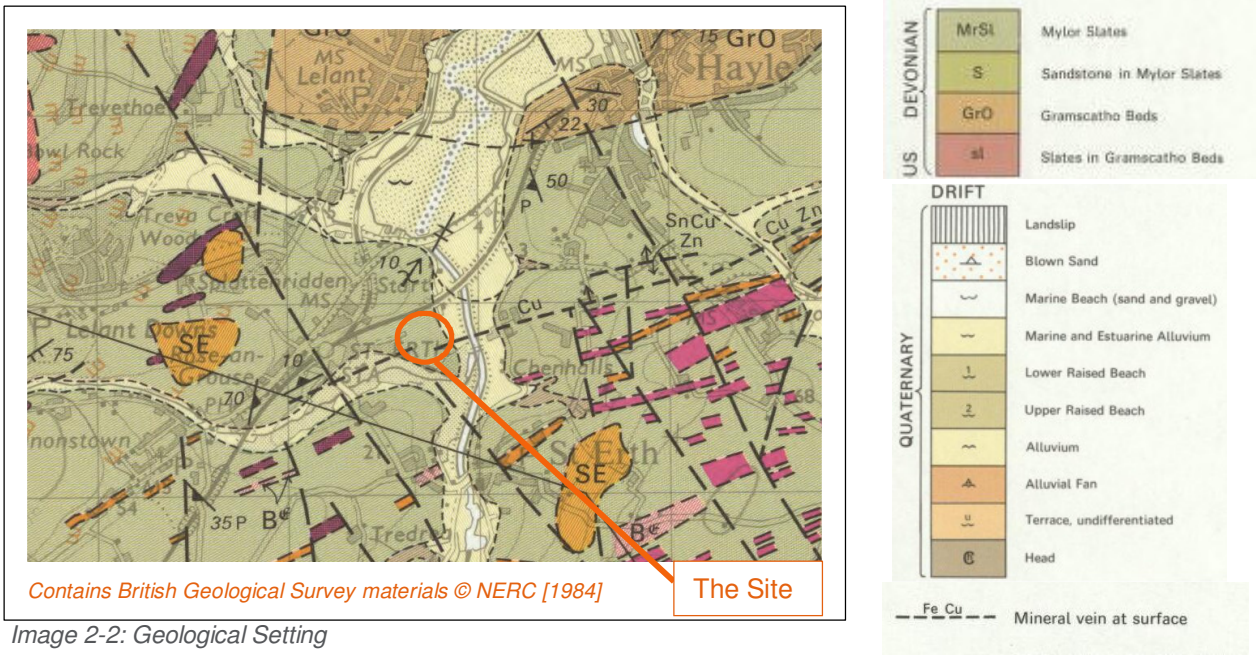
The River Hayle is situated 50 m east of Hayle WwTw, and 200m east of the location of the ground investigation works. The River Hayle flows to the north into the Hayle Estuary, and travels approximately 600m through the estuary and out into St Ives Bay. St Erth railway station is situated approximately 450m to the west of the site, with the Great Western Railway line passes 90 m north of the sewage treatment works in a southwest to northeast orientation. To the immediate west of the site is a large recycling centre. To the north of the site the A30 and the town of Hayle are located; whereas the land to the east, west and south which is predominantly occupied by woodland areas, with farmland and agricultural fields beyond.

The historic landfill of Lelant Saltings is located 800m northwest of the site, which was operated by Penwith Rural District Council and accepted wastes of inert, industrial, commercial and household. The historic landfill last received waste in 1969 [21].

Approximately 1.1 km to the southeast of the site lies the St Erth Sand Pits, which is known for its sequence of Late Pliocene marine sediments, containing exceptionally diverse fossils. In 1962 the St Erth Sand Pits became a Site of Scientific Interest due to the significant fossil finds, and providing a unique source of evidence relating to the geomorphological evolution of SW England [22].

2.2 Geology

The published 1:50 000 scale British Geological Survey (BGS) map of the area incorporating the site, Sheet 351 & 358 [2], and the BGS online GeoIndex [18] indicate the site is underlain by Devonian Mylor Slates. The general distribution of the strata at the site is shown in Image 2-2.



Contains British Geological Survey materials © NERC [1984]

Image 2-2: Geological Setting

The Mylor Slates Formation is a sedimentary bedrock consisting of slate and siltstone. It was formed approximately 359 to 385 million years ago, during the Devonian Period, with the local environment dominated by open seas with pelagite deposits [18].

Image 2-2 indicates the presence of a mineral seam, noted as copper, orientated in a west-southwest to east-southeast direction through the southern half of the site [19].

The northeast corner of the site is indicated to be underlain by alluvium deposits due to the close proximity to the River Hayle. The alluvium deposits were formed during the Quaternary Period, and consist of soft to firm silty clay, and may also contain layers of silt, sand, peat and basal gravel [18].

2.3 Hydrogeology and Hydrology

The River Hayle is located 50 m to the east of the sewage treatment works, and is approximately 12 miles long. The river flows north into the Hayle Estuary, and then into St Ives Bay. The Hayle Estuary and Carrack Gladden is noted as a Site of Scientific Interest due to its biological interest across the extensive area of intertidal mudflats and salt marshes [23]. The Hayle Estuary's mean high water boundary is 600m north of the site, and poses a low flood risk to the site area, with only the northeast corner of the site at potential risk of annual flooding between 0.1-1% [20].

The BGS indicates the hydrogeology in the area is that of Upper Devonian Rocks, with a low productivity multi-layered aquifer with small local yields from secondary fractures [19].

The Environment Agency details the groundwater in the area of the site is at risk from nitrate pollution and sediment losses due to high agricultural land use in the surrounding farmland area [24].

3 FIELDWORK

3.1 General

Ground investigation works were carried out between 16th and 19th May 2016. The scope of the ground investigation, including the location, scheduled depth and type of exploratory hole undertaken was determined by Arcadis Consulting (UK) Ltd and is summarised in Table 3-1.

The ground investigation methods were undertaken in general accordance with the principles set out in BS EN 1997-2:2005 [8] and with the general practice described in BS5930:2015 [9]. The geo-environmental aspects of the ground investigation complied with the general requirements of BS 10175:2011+A1:2013 [10].

Table 3-1 Initial ground investigation scope

Location ID	Hole Type	Scheduled Depth (m)	Requirements
BH01	DS+RC	10.0	Determine thickness of engineering soils; penetrate 3 m into bedrock; determine rock weathering profile; collect representative samples of strata and undertake in situ tests
BH02	DS+RC	10.0	Determine thickness of engineering soils; penetrate 3 m into bedrock; determine rock weathering profile; collect representative samples of strata and undertake in situ tests
BH03	DS+RC	8.0	Determine thickness of engineering soils; penetrate 3 m into bedrock; determine rock weathering profile; collect representative samples of strata and undertake in situ tests

Notes
DS = dynamic sampling, RC = rotary core drilling,

The investigation works were carried out under the supervision of a suitably experienced ground investigation engineer who undertook the logging and reporting of the exploratory holes and in situ testing.

3.2 Exploratory Holes

3.2.1 Exploratory Hole Locations

The co-ordinates and elevations of the exploratory hole locations were obtained by the Arcadis supervising engineer using a Trimble VRS NOW GPRS system; allowing an accuracy of +/-50 mm.

Drawing UA008501-GLR-DWG-0001 presented in Appendix A displays the as-constructed exploratory hole locations while the co-ordinates and elevation of the ground surface at each exploratory hole location are given on the individual logs.

The location of the exploratory holes has been designed due to the locations of the proposed works; BH01 and BH02 are in the proposed location of the new vortex grit trap, whereas BH03 is located in the area of the bypass channel and fine screens.

3.2.2 Investigation Methodology

The following methods and techniques were undertaken to construct the exploratory holes at the site. The completed scope of investigation is summarised in Table 3-2 below.

Details of the methods of investigation and associated standards adopted are presented in Appendix B; the exploratory hole records are presented in Appendix C, a key to the notation and symbols used on the logs is presented in Appendix B.

Table 3-2. Summary of completed exploratory holes

Location ID	Hole Type	Start Date	End Date	Final depth (m)	Comment	Termination Reason
BH01	DS+RC	18 May 2016	18 May 2016	10.25	Successful in penetrating 3m into bedrock	Target depth
BH02	DS+RC	17 May 2016	17 May 2016	7.90	Successful in penetrating 3m into bedrock	Target depth
BH03	DS+RC	16 May 2016	17 May 2016	5.20	Successful in penetrating 3m into bedrock	Target depth

Notes
, DS = dynamic sampling. RC = rotary core drilling,

3.2.3 Rotary Drilling

Rotary core hole drilling was undertaken using a type of rig mounted on a trailer. The drilling used standard PWF double-tube core barrels with a type of bit and casing to produce core/open hole of 0.3 m diameter. The boreholes were advanced using a recirculating water flush.

Where the specified core recovery was not achieved, the length of core run was reduced on subsequent core runs until recovery improved.

Recovered cores were retained in appropriately sized semi-rigid plastic liners and placed in wooden core boxes for transport and logging. Photographs of each core box showing the recovered cores are presented with the appropriate rotary borehole log.

Sub-samples of core were removed from the core runs at intervals specified by Arcadis Consulting (UK) Ltd for subsequent laboratory testing, the location of the sub-samples was indicated by placing wood sections to represent the core removed.

3.2.4 Dynamic Sampling

Dynamic sampling was completed using a track-mounted sampling rig capable of driving windowless sampling tubes using a mechanical hammer dropped repeatedly from a height. The choice of method was largely dictated by access conditions at the site.

The time to drive the sampling tubes (or number of blows for the mechanical hammer) was recorded together with a description of the recovered materials by the supervising engineer or the lead driller.

Photographs of the materials recovered are presented with the appropriate exploratory hole log. To enable a representative photographic record, the samples were split prior to the photograph and subsequently destructively logged.

Due to the method of investigation, the materials recovered within the sampler apparatus were generally disturbed and were assessed as complying with Class 3 to Class 5 of BS EN 22475-2. Sub-samples of the material recovered in the liners were taken to enable representative laboratory testing. Generally small disturbed samples were taken at each change in strata.

Where specified by Arcadis Consulting (UK) Ltd open drive tube samples were taken using thin-walled sampling apparatus from the relatively undisturbed material at the base of the borehole following extraction of the preceding sample tube.

Standard penetration tests (SPTs) were undertaken using the track mounted rig at 1.5 m centres until the termination depth of the hole.

3.3 In situ Testing

3.3.1 General

In situ testing was either carried out within the relevant exploratory hole. Where tests were undertaken within or associated with a specific borehole or trial pit, the test data is presented within the relevant exploratory hole log or it is provided as additional sheets to that log. As such, the location details will be the same as the associated hole and its position will be the same as the exploratory hole with which it is associated.

3.3.2 Penetration Testing

3.3.2.1 Standard Penetration Tests

Standard penetration tests (SPTs) were carried out as required in the investigation scope and in accordance with the methods given in the standard procedures presented within Appendix B. Generally tests were undertaken at regular intervals throughout the borehole to provide a profile of the soil's resistance with depth and a disturbed soil sample was recovered from the SPT split-spoon tool or a disturbed sample was taken over the range of the test interval.

The N-values as determined in the field are presented on the borehole logs as uncorrected values that do not take into account the energy losses or efficiency of the automatic trip hammer used to drive the test tool into the ground. The calibration certification for the test devices used in the investigation is presented in Appendix D and a summary of the SPT equipment used at each location is presented in Table 3-3.

Table 3-3 SPT equipment

Location ID	SPT Hammer Reference No.	Energy Efficiency Ratio, E_r %	Comment
BH01	CC04	71.07	
BH02	CC04	71.07	
BH03	CC04	71.07	

3.3.2.2 Dynamic Probing

Dynamic probing was carried out as required in the investigation scope and in accordance with the methods given in the standard procedures presented within Appendix B using a Fraste Multidrill rig configured to enable super-heavy dynamic probing using a 63.5 kg hammer mass and with a 750 mm drop DPSH-B as required by the investigation scope.

The penetration resistance of the test cone was determined by the number of blows of the free-fall hammer required to drive the test cone a distance of 100 mm, (N_{100}). A continuous record of the resistance is provided by the test to the required depth. At intervals corresponding to the length of the extension rods, the torque required to turn the below ground test assembly was determined.

The test was terminated at the required depth or where the number of blows exceeded 100 blows per 100 mm or where the torque required to turn the rods exceeded 200 Nm or where the inclination of the rods was more than 5° from the vertical.

The test results are presented in Appendix C as profiles of the N_{100}-values together with the torque readings and an interpretation of the soil type where this has been assessed from adjacent boreholes. The N_{100}-values are uncorrected and do not take into account the energy losses or efficiency of the automatic free-fall hammer used to drive the test cone. The calibration certification showing the energy ratio E_r for the hammer system used in the investigation is presented in Appendix D.

4 LABORATORY TESTING

4.1 General

Geotechnical and geo-environmental chemical testing was undertaken on selected samples obtained from the exploratory holes. The testing was scheduled by the geotechnical and/or geo-environmental engineer and the testing was undertaken by an Arcadis approved testing laboratory.

4.2 Geotechnical Laboratory Testing

The geotechnical tests detailed in Table 4-1 were carried out in accordance with either BS1377:1990: Parts 1 to 8 [15]; BS EN ISO 17892: Parts 1 to 12 [16]; BRE SD 1:2005 [6]; or other methods as listed in Table 4-1.

Table 4-1 Summary of geotechnical test data

Test	Method	No of Determinations	Comment
pH, water soluble sulphate; total sulphate, total sulphur, chloride, nitrate, magnesium	BRE SD1 preferred methods	9	

4.3 Geo-Environmental Laboratory Testing

Geo-environmental tests were undertaken on soil, obtained from the samples collected from the site. Testing was carried out for the pH detailed in
Table 4-2.

Table 4-2 Summary of geo-environmental test data – soil matrix

Test type	Method	No of Determinations
pH		9

5 REFERENCES

General References

1. Arcadis Consulting. 2015. Pre-construction information for Hayle WwTw Arcadis Consulting. May 2016.
2. British Geological Survey. 1984. Penzance. England and Wales Sheet 351 & 358. Bedrock and Drift Deposits. 1:50 000. BGS Keyworth, Nottingham.
3. TRL. 2004. Dynamic cone penetrometer tests and analysis. TRL Technical Report PR IN 277-04. Transport Research Laboratory, Crowthorne, England.
4. Jones C R and Rolt J. 1991. Operating instructions for the TRL dynamic cone penetrometer. 2nd Edition Information Note. Transport Research Laboratory, Crowthorne.
5. Building Research Establishment. 2016. Soakaway Design. BRE Digest DG365. BRE, Watford.
6. Building Research Establishment. 2005. Concrete in aggressive ground. BRE Special Digest 1. 3rd Edition. BRE, Watford.

National Standards

7. BS EN 1997-1. 2004. Eurocode 7: Geotechnical Design. Part 1 General Rules. British Standards Institution, 2013 (revised text).
8. BS EN 1997-2. 2007. Eurocode 7: Geotechnical Design. Part 2 Ground Investigation and testing. British Standards Institution, 2010 (revised text).
9. BS 5930. 2015. Code of practice for ground investigations. British Standards Institution.
10. BS 10175+A1:2013. 2011. Investigation of potentially contaminated sites – Code of practice. British Standards Institution.
11. BS EN ISO 22282-1:2012. Geotechnical investigation and testing – Geohydraulic testing. Part 1: General Rules. British Standards Institution.
12. BS EN ISO 22282-2:2012. Geotechnical investigation and testing – Geohydraulic testing. Part 2: Water permeability tests in a borehole using open systems. British Standards Institution.
13. BS EN ISO 22282-5:2012. Geotechnical investigation and testing – Geohydraulic testing. Part 5: Infiltrometer tests. British Standards Institution.
14. BS EN ISO 22282-6:2012. Geotechnical investigation and testing – Geohydraulic testing. Part 6: Water permeability tests in a borehole using closed systems. British Standards Institution.
15. BS 1377. 1990. Method of test for soils for civil engineering purposes. Published in 9 Parts. British Standards Institution,
16. BS EN ISO 17892-1: Geotechnical investigation and testing – Laboratory testing of soil – Determination of water content. British Standards Institution.
17. BS EN ISO 17892-2: Geotechnical investigation and testing – Laboratory testing of soil – Determination of bulk density. British Standards Institution.

Internet References

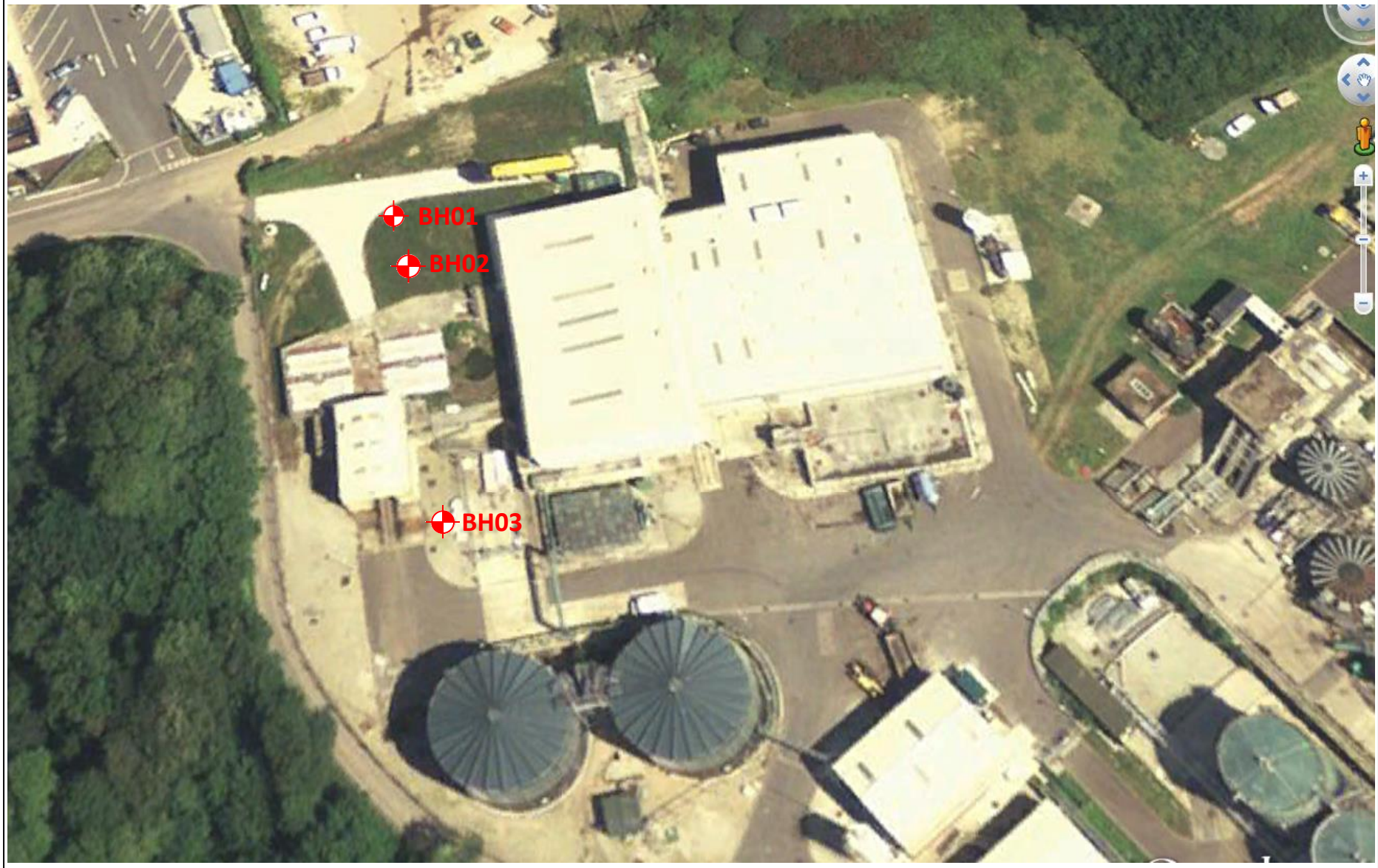
18. British Geological Survey: http://www.bgs.ac.uk/data/maps/maps.cfc?method=viewRecord&mapId=10453 . Accessed May 2016.
19. British Geological Survey; Geoindex Onshore: http://mapapps2.bgs.ac.uk/geoindex/home.html Accessed May 2016.
20. Environment Agency: WIYBY Flooding Risks http://watermaps.environment-agency.gov.uk/wiyby/WiybyMapQueryResults.aspx?lang=_e&scale=11&cx=154517&cy=35807&topic=floodmap&layerid=0&x=154803&y=35929. Accessed May 2016.

21. Environment Agency: WIYBY Landfill http://maps.environment-agency.gov.uk/wiyby/wiybyController?latest=true&topic=waste&ep=query&lang=_e&x=154460.99999999999997&y=36733.22916666679&scale=9&layerGroups=2&queryWindowWidth=25&queryWindowHeight=25 Accessed May 2016.
22. SSSI Nature England: St Erth Sand Pits http://www.sssi.naturalengland.org.uk/citation/citation_photo/1000492.pdf Accessed May 2016
23. SSSE Nature England: Hayle Estuary and Carrack Gladden http://www.sssi.naturalengland.org.uk/citation/citation_photo/1003229.pdf Accessed May 2016
24. Environment Agency; WIYBY for Farmers http://maps.environment-agency.gov.uk/wiyby/wiybyController?latest=true&topic=farming&ep=query&lang=_e&x=154748.583333333358&y=35759.04166666666&scale=9&layerGroups=1&queryWindowWidth=3&queryWindowHeight=3 Accessed June 2016

APPENDIX A

DRAWINGS

Drawing UA008501-GLR-EHP-0001: Exploratory Hole Location Plan



Client

SOUTH WEST WATER

Status: Final

Scale: NTS

Current Issue Signatures

Datum	N/A	Author	S Carter
Grid	N/A	Checker	C Pristavec
© Copyright Reserved		Approver	D Hicks

Project: Hayle WwTw Inlet

Title: Exploratory Hole Location Plan

ARCADIS
Arcadis Consulting (UK) Ltd
Arcadis House
Fortran Road
Cardiff
CF3 0EY
Tel: 02920 926 700
Fax: 02920 799 275

Drawing No.	Project No.	Issue No.
001	UA008501	01

APPENDIX B

STANDARD PROCEDURES

B0 General Principles

This ground investigation was undertaken in general accordance with the principles of BS EN 1997-1 [1] and BS EN 1997-2 [2] and the advice given in BS5930:2015 [8], which, provides complimentary guidance on the application of the primary standards. Where the requirements of the ground investigation specification differ from these primary standards, the investigation methodology was adapted as required and specific notes regarding methods and techniques employed were made in the appropriate report sections.

B1 Buried Services

Service clearance was undertaken in accordance with Arcadis' common operating practice COP SA1. This document details the methods and safe working practices used to undertake excavations safely. Prior to breaking ground, services plans were consulted and the area scanned using a Cable Avoidance Tool (CAT) with detected signals marked on the ground. For all investigation positions, other than for machine excavated trial pits, hand excavated inspection pits are completed to 1.20 m bgl prior to the use of drilling and boring plant.

B2 Sampling requirements

The selection of sample types and sampling techniques has been chosen to take account of the soil fabric, size and quality of sample required based on whether the soils mass properties or the intact material properties of the ground are to be determined in subsequent laboratory tests. BS EN ISO 22475-1 [4] describes three generic sample groups that are:

a. Sampling by drilling. Generally a disturbed sample recovered from the drilling tool or digging equipment, typically meeting Class 3 to Class 5 requirements, with the recovered material being stored in bulk bags or sealed jar or tub containers.
b. Sampling by sampler. Typically referred to as open tube or drive sampling in which a tube with a sharp cutting edge is driven into the ground either by static thrust or dynamically driven to give a relatively undisturbed sample of Class 1 or Class 2 but may result in a Class 3 sample.
c. Block sampling. Cylindrical large diameter samples or cuboid hand-cut samples usually relatively undisturbed Class 1 and Class 2.

The open-tube sampling equipment used on the site was of a type and design that conformed to BS EN ISO 22475-1. For the purpose of this ground investigation block sampling was not required.

Generally samples were assessed on site and any unexpected deterioration in sample quality was reported to the ground engineer by the lead drilling technician.

Sufficient and representative samples were taken to allow the geo-mechanical properties of the ground to be adequately characterised and to enable the sequence of soil strata to be described by an engineering geologist or geotechnical engineer.

Where samples have been taken for chemical tests the drilling method attempted to adopt dry drilling over the sampling range that generally was achieved by the use of drill casing to separate and isolate the upper soil layers and exclude groundwater. Cross-contamination was further reduced by regular cleaning of sampling tools. Sample integrity was maintained by sealing samples immediately on collection and storing the samples in a temperature controlled cool box. Samples were despatched from the site at the end of the shift on which they were collected or as

required in the project specification. Details of best practice storage, preservation and decontamination measures undertaken are given below:

Task	Soil	Groundwater	Ground Gas
Storage	Glass jars and vials supplied by the laboratory were used for the collection of soil samples to be analysed for volatile compounds. Plastic one-litre tubs were used to collect soil samples for metals analysis.	Glass vials supplied by the laboratory were used for the collection of samples to be analysed for volatile compounds. Samples to be analysed for lower volatility compounds were stored in laboratory prepared glass bottles.	1.4L Canisters supplied by the laboratory.
Preservation	Filling of sample containers as far as practicable to minimise headspace and low storage temperature to minimise the potential for volatilisation and biodegradation of petroleum hydrocarbon compounds prior to analysis.		Not required.
Decontamination	Disposable gloves were worn and changed between sample collection to prevent cross-contamination.	Groundwater samples were collected using dedicated disposable tubing / bailers, that were changed between monitoring well locations in order to prevent cross-contamination.	Disposable gloves were worn and changed between sample collection to prevent cross contamination.
Transport	Samples stored in dedicated sample boxes provided by the laboratory. Sample details and analytical requests were recorded on the laboratory chain of custody form included with samples, prior to dispatching to laboratory for analysis. Samples were dispatched to the laboratory on the day of sampling.		

B3 Sample description

Sample description was undertaken by the Arcadis site geologist in accordance with BS 5930: 2015. The descriptions of the individual samples were used to identify the sequence of strata at the exploratory hole location and from which representative exploratory hole logs were drawn.

B4 In situ testing

In situ geotechnical tests were undertaken taking account of the investigation scope and requirement to attain the appropriate parameters required in the geotechnical design. The tests were undertaken in accordance with the requirements of the relevant parts of BS EN ISO 22476 [5, 6, 7] and other methods as follows:

Dynamic probing

Dynamic probes were undertaken in general accordance with BS EN ISO 22476-2, BS EN 1997-2 and the national annex to BS EN 1997. The tests were generally made using the super-heavy DPSH-B configuration of the apparatus, however, it should be noted that the basis for selection of the type of dynamic probe should be a consideration of the driving energy in relation to the type of ground conditions anticipated at the site.

Where adequate correlation with borehole data is available an interpretation of the estimated soil type may be made, however, it should be noted that probing can give unreliable results in mixed soils.

Standard penetration testing

Standard penetration tests were carried out in accordance with BS EN ISO 22476-3, BS EN 1997-2 and the national Annex to BS EN 1997-2. The test records are presented on the borehole logs as blow counts for each increment with the N-value as the total number of blows of the four main test increments.

Where the N-value exceeds a total of 50 blows, the test reports the penetration in millimetres for the last test increment recorded, and the N value is indicated as greater than 50,

e.g. 4,5/12,14,18, 6 for 10 mm

indicates that the seating blows (4 and 5) were completed and that the test terminated in the 4th increment after penetrating 10 mm.

Where the seating blows exceeded 25 blows for less than 150 mm; the test was stopped and the rods remarked after which, the main drive was continued. The test is then reported as the number of blows in each seating drive for the recorded penetration with the results of the main drive given as above,

e.g. 14/11 for 45 mm/12,14,16, 8 for 10 mm.

In certain circumstances where groundwater in-flow may affect the test, particularly in fine sand or silt, low SPT blow counts may be recorded. Where the SPT blow count was very low, N values of 5 or less, the test was, at the discretion of the site engineer, continued for a further 300 mm, recording blows for each 75 mm increment. **This is not** a standard penetration test value, it does however give an indication of potential disturbance to the ground.

California Bearing Ratio

In situ California Bearing Ratio (CBR) tests were carried out in general accordance with the requirements of BS 1977-9:1990, 4.3 [10]. The CBR is a strength test that is generally concerned with pavement design and the control of pavement sub grade construction, as such it is a test that is most suited to soils with a maximum particle size not exceeding 20 mm.

B5 Data transfer format

The data collated during the ground investigation has been organised and managed using the “AGS data format” that allows data transfer between different disciplines and organisations in accordance with BS 8574 [9].

B6 References

1. BS EN 1997-1. 2004. Eurocode 7: Geotechnical Design. Part 1 General Rules. British Standards Institution, 2013 (revised text).
2. BS EN 1997-2. 2007. Eurocode 7: Geotechnical Design. Part 2 Ground Investigation and testing. British Standards Institution, 2010 (revised text).
3. BS EN ISO 22282-1:2012. Geotechnical investigation and testing – Geohydraulic testing. Part 1: General Rules. British Standards Institution.
4. BS EN ISO 22475-1. Geotechnical investigation and testing – Sampling methods and groundwater measurements – Part 1 Technical principles for execution.
5. BS EN ISO 22476-1:2015. Geotechnical investigation and testing – Field testing – Part 1: Electrical cone and piezocone test. British Standards Institution
6. BS EN ISO 22476-2. Geotechnical investigation and testing – Field testing – Part 2: Dynamic Probing. British Standards Institution
7. BS EN ISO 22476-3 2005. Geotechnical investigation and testing – Field testing – Part 3: Standard penetration test. British Standards Institution
8. BS 5930: 2015. Code of practice for ground investigation. British Standards Institution.
9. BS 8574. Code of practice for the management of geotechnical data for ground engineering projects.
10. BS 1377-9. 1990. Methods of test for soils for civil engineering purposes. Part 9: In-situ tests. British Standards Institution.
11. TRL. 2004. Dynamic cone penetrometer tests and analysis. TRL Technical Report PR IN 277-04. Transport Research Laboratory, Crowthorne, England.

B7 Exploratory Hole Key

Key to Exploratory Hole Symbols and Abbreviations

SAMPLE TYPES

B	Bulk disturbed sample	ES	Environmental soil sample	U	Undisturbed sample
C	Core sample	EW	Environmental water sample	UT	Undisturbed thin wall sample
CBR-D	Disturbed sample from CBR test area	G	Gas sample	W	Water sample
CBR-U	Undisturbed sample from CBR test area	L	Liner sample		
D	Small disturbed sample	SPT	SPT split spoon sample		

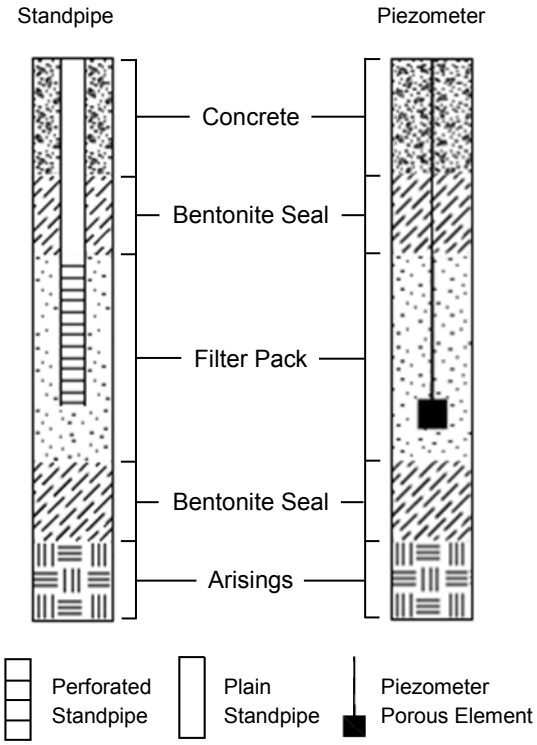
IN-SITU TESTING

SPTs	Standard Penetration Test (using a split spoon sampler)
SPTc	Standard Penetration Test (using a solid 60 degree cone)
N	Recorded SPT 'N' Value *
-/-	Blows/Penetration (mm) after seating blows totalling 150 mm
MX	Mexi Probe Test (records CBR as %)
HV	Hand Shear Vane Test (undrained shear strength quoted in kPa)
PP	Pocket Penetrometer Test (kg/m^3)
( )	Denotes residual test value
PID	Photo Ionisation Detector (ppm) *
Kf/Kr	Permeability Test (f = falling head, r = rising head quoted in ms^{-1})
HPD	High Pressure Dilatometer Test (pressure meter)
PKR	Packer / Lugeon Permeability Test
CBR	California Bearing Ratio Test

ROTARY CORE DETAILS

TCR	Total Core Recovery, %
SCR	Solid Core Recovery, %
RQD	Rock Quality Designation (% of intact core >100 mm)
FI	Fracture Spacing (average fracture spacing; in mm, over indicated length of core) * *
NI	Non-Intact Core
AZCL	Assumed Zone of Core Loss

INSTALLATION & BACKFILL DETAILS



GROUNDWATER

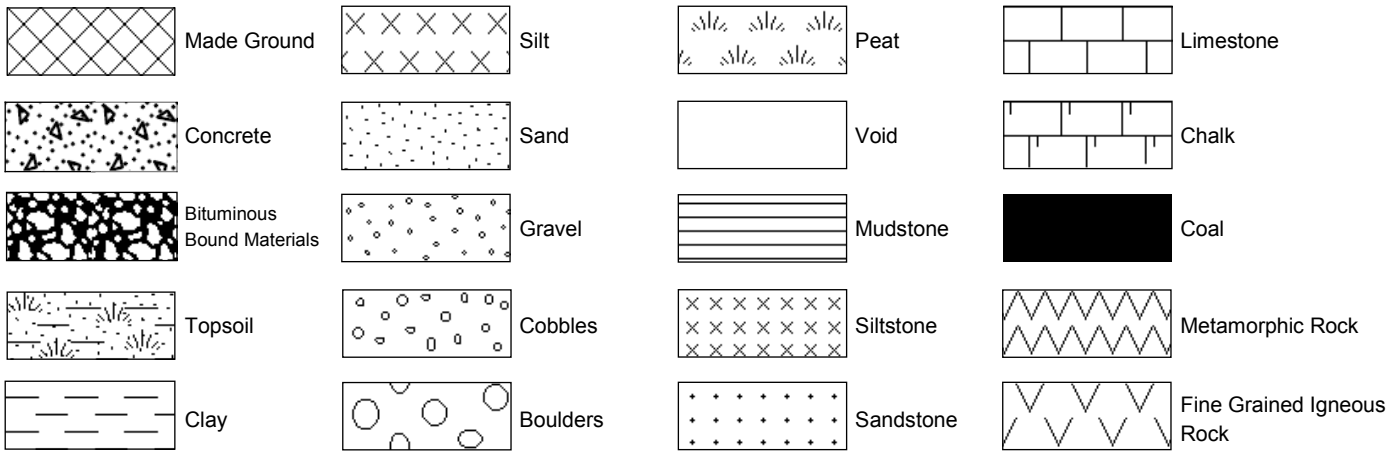
Groundwater strike

Standing water level after 20 minutes; 1st, 2nd etc (number denotes level order)

STRATUM BOUNDARIES

Unit boundary

STRATA LEGENDS - Note: Composite strata types are shown by combining symbols



* Where a single value is quoted this is the uncorrected 'N' value for a full 300 mm test drive following a seating drive of 150mm. Where the full test drive penetration is not achieved the number of blows is quoted for the penetration below the test total of 300mm, e.g.: 50/75.

* * The minimum, average and maximum are shown e.g. 5/45/125.

APPENDIX C

EXPLORATORY HOLE LOGS

ARCADIS Rotary Borehole Log

BH01

Project	Project No.	Ground Level (mAOD)	Start Date	Scale
Hayle Inlet WwTW	**UA008501**	**10.71**	**18/05/2016**	**1:50**
Client	Easting (OS mE)	Northing (OS mN)	End Date	
South West Water	**154613.60**	**35816.96**	**18/05/2016**	**Sheet 1 of 2**

SAMPLES		TESTS		DRILL LOG			Water Strikes	PROGRESS		STRATA				
Depth	Type/ No.	Type/ No.	Results	TCR% SCR% RQD%	FI (min ave max)	Flush Rtn%		Date Time	Casing Water	Description	Legend	Depth (Thickness)	Level	Install/ Backfill
0.10 - 0.20	B1									Grass over brown sandy gravelly CLAY.		0.10	10.61	
0.10 - 0.20	ES1									MADE GROUND: Soft to firm brown slightly sandy slightly gravelly CLAY with low cobble content and many rootlets. Gravel is angular to subrounded fine to coarse of mudstone and slate. Cobbles are angular of mudstone and slate.		0.20	10.51	
0.20 - 0.50	B1											(0.30)		
0.20 - 0.50	ES1											0.50	10.21	
0.50 - 1.00	B1									MADE GROUND: Yellowish brown slightly clayey gravelly SAND with low cobble content. Gravel is angular to subrounded fine to coarse of mudstone and slate.Cobbles are angular of mudstone and slate.		(0.70)		
0.50 - 1.00	ES1													
1.20	D1	SPT(S)	N=23 (2,5/9,5,4,5)				Dry	18/05/2016 09:00	0.00 Dry	MADE GROUND: Yellowish brown slightly clayey very sandy GRAVEL with low cobble content. Gravel is angular to subrounded fine to coarse of mudstone and slate. Cobbles are angular to subrounded of mudstone and slate.		1.20	9.51	
1.20 - 2.20	NU1													
2.00 - 2.10	ES1									MADE GROUND: Orangish brown locally grey sandy clayey GRAVEL with low to medium cobble content. Gravel is angular to subrounded fine to coarse of slate and mudstone with occasional gypsum crystals.				
2.20	D1	SPT(S)	N=18 (3,5/4,5,4,5)				Dry							
2.20 - 3.20	NU											(3.00)		
2.80 - 2.90	ES1													
3.20	D1	SPT(S)	N>50 (11,14 for 65mm/26,24 for 35mm)				Dry							
3.20 - 4.20	C1													
4.20	D1	SPT(S)	N>50 (13,12 for 45mm/13,14,17,6 for 15mm)			100	0.1			Poor recovery. Recovery material comprises weak to medium strong grey SLATE non intact; recovered as angular coarse gravel with pervasive orange brown staining. [MYLOR SLATE FORMATION]		4.20	6.51	
4.20 - 5.70	C1			30 0 0	0 0							(1.50)		
5.70 - 6.00	C1			100						Stiff grey very gravelly CLAY. Gravel is angular fine and medium of slate [MYLOR SLATE FORMATION]		5.70	5.01	
6.00 - 7.00	C1	SPT(C)	N=34 (9,8/11,11,6,6)	67 0 0			3.2					(1.30)		
7.00 - 8.50	C1									Stiff grey very gravelly CLAY. Gravel is angular fine and medium of slate. [MYLOR SLATE FORMATION]		7.00	3.71	
8.20 - 8.30	ES1													
8.50 - 8.70	NU1											(3.25)		
8.70 - 8.80	NU1	SPT(C)	N=21 (8,9/7,5,5,4)				3.94							
8.80 - 9.80	C1													
		SPT(C)	N=17 (6,5/3,5,4,5)				4.25	18/05/2016 17:30	4.20 4.25					

Continued on next page

DRILLING TECHNIQUE			FLUSH DETAILS				WATER OBSERVATIONS						HOLE/CASING DIAMETER				WATER ADDED		
Depth Top	Depth Base	Type	From	To	Rtn %	Flush Type	Date/Time	Strike At	Time Elapsed	Rise To	Casing	Sealed	Hole Dia.	Depth	Casing Dia.	Depth	From	To	Volume (ltr)
0.00	1.20	Inspection Pit	4.20	9.80	100	Water							140	4.20	140	4.20			
1.20	3.20	Dynamic Sample											10	50.00					
													10	116.00					

Remarks

No groundwater encountered prior to the use of water flush. Borehole terminated on Engineer's instruction.

Termination Depth: 10.25m

HCL House St Mellons Business Park Cardiff CF3 0EY

Unless otherwise stated: Depth (m), Diameter (mm), Time (hhmm), Thickness (m), Level (mAOD).

Equipment Used	Contractor	Logged By	Checked By
Fraste Multidrill	**Arcadis Consulting (UK) Ltd**	**SC**	**PAW**

ARCADIS Rotary Borehole Log

BH01

Project	Project No.	Ground Level (mAOD)	Start Date	Scale
Hayle Inlet WwTW	**UA008501**	**10.71**	**18/05/2016**	**1:50**
Client	Easting (OS mE)	Northing (OS mN)	End Date	
South West Water	**154613.60**	**35816.96**	**18/05/2016**	**Sheet 2 of 2**

SAMPLES		TESTS		DRILL LOG			Water Strikes	PROGRESS		STRATA		Depth (Thickness)	Level	Install/ Backfill
Depth	Type/ No.	Type/ No.	Results	TCR% SCR% RQD%	FI (min ave max)	Flush Rtn%		Date Time	Casing Water	Description	Legend			
												10.25	0.46	

DRILLING TECHNIQUE			FLUSH DETAILS				WATER OBSERVATIONS						HOLE/CASING DIAMETER				WATER ADDED		
Depth Top	Depth Base	Type	From	To	Rtn %	Flush Type	Date/Time	Strike At	Time Elapsed	Rise To	Casing	Sealed	Hole Dia.	Depth	Casing Dia.	Depth	From	To	Volume (ltr)
0.00	1.20	Inspection Pit	4.20	9.80	100	Water							140	4.20	140	4.20			
1.20	3.20	Dynamic Sample											10	50.00					
													10	116.00					

Remarks

No groundwater encountered prior to the use of water flush. Borehole terminated on Engineer's instruction.

Termination Depth: 10.25m

HCL House
St Mellons
Business Park
Cardiff
CF3 0EY

AGS

Unless otherwise stated:
Depth (m), Diameter (mm), Time (hhmm), Thickness (m), Level (mAOD).

Equipment Used	Contractor	Logged By	Checked By
Fraste Multidrill	**Arcadis Consulting (UK) Ltd**	**SC**	**PAW**

ARCADIS Rotary Borehole Log

BH02

Project	Project No.	Ground Level (mAOD)	Start Date	Scale
Hayle Inlet WwTW	**UA008501**	**10.65**	**17/05/2016**	**1:50**
Client	Easting (OS mE)	Northing (OS mN)	End Date	
South West Water	**154610.10**	**35808.35**	**17/05/2016**	**Sheet 1 of 1**

SAMPLES Depth	SAMPLES Type/ No.	TESTS Type/ No.	TESTS Results	DRILL LOG TCR% SCR% RQD%	DRILL LOG FI (min ave max)	DRILL LOG Flush Rtn%	Water Strikes	PROGRESS Date Time	PROGRESS Casing Water	STRATA Description	STRATA Legend	Depth (Thickness)	Level	Install/ Backfill
0.10 - 0.20	B1							17/05/2016 10:30	0.00 0.00	Grass brown gravelly sandy CLAY.		0.10	10.55	
0.10 - 0.20	ES1									MADE GROUND: Brown slightly clayey very gravelly SAND with low cobble content and occasional rootlets. Gravel is angular to subrounded fine to coarse of concrete, slate and ballast. Cobbles are angular to subrounded of concrete.		0.20 (0.30)	10.45	
0.20 - 0.50	B1											0.50	10.15	
0.20 - 0.50	ES1													
0.50 - 1.00	B1													
0.50 - 1.00	ES1													
										MADE GROUND: Light brown slightly clayey very sandy GRAVEL with low cobble content. Gravel is angular to subrounded fine to coarse of concrete, ballast and mudstone. Cobbles are angular to subrounded of concrete.				
1.20 - 1.65	D1	SPT(C)	N=5 (1,1/1,2,1,1)				Dry							
1.20 - 2.00	NU1													
										MADE GROUND: Orangish brown slightly clayey very sandy GRAVEL with low cobble content. Gravel is angular to subrounded fine to coarse of slate, concrete, and mudstone.				
1.80 - 1.90	ES1											(2.50)		
2.00 - 3.00	NU1	SPT(S)	N=23 (3,4/5,6,6,6)				Dry							
2.70 - 2.80	ES1													
3.00 - 3.45	D1	SPT(S)	N=24 (4,5/6,6,6,6)				Dry					3.00	7.65	
3.00 - 3.80	NU1									MADE GROUND. Yellow orangish brown locally grey very sandy slightly clayey GRAVEL. Gravel is angular to subrounded fine to coarse of slate and mudstone.		(0.80)		
3.80 - 4.10	UT1					100						3.80	6.85	
3.80 - 5.30	C1									Weak to medium strong grey SLATE; non intact recovered as angular to subrounded GRAVEL. Orange brown discolouration in fracture surfaces. [MYLOR SLATE FORMATION]				
4.10 - 4.20	D1													
				100	0							(1.50)		
				17	0									
				10	0									
5.30 - 6.80	C1	SPT(C)	N>50 (4,21 for 65mm/29,21 for 55mm)				1.12			Medium strong grey SLATE. Fractures are subhorizontal closely spaced planar smooth and rough locally infilled with clay. Reduction in strength to very weak and weak along fracture surfaces with orange discolouration. [MYLOR SLATE FORMATION]		5.30	5.35	
				100										
				67										
				10										
					0							(2.60)		
					100									
					250									
6.80 - 7.90	C1									Non intact.				
				73										
				40										
				0										
								17/05/2016 00:00	3.80 3.80			7.90	2.75	

DRILLING TECHNIQUE			FLUSH DETAILS				WATER OBSERVATIONS						HOLE/CASING DIAMETER				WATER ADDED		
Depth Top	Depth Base	Type	From	To	Rtn %	Flush Type	Date/Time	Strike At	Time Elapsed	Rise To	Casing	Sealed	Hole Dia.	Depth	Casing Dia.	Depth	From	To	Volume (ltr)
0.00	1.20	Inspection Pit	3.80	7.90	100	Water							140	3.80	140	3.80			
1.20	3.80	Dynamic Sample											116	7.90					

Remarks

No groundwater encountered prior to the use of water flush. Borehole terminated on Engineer's instruction.

Termination Depth: 7.90m

ARCADIS Rotary Borehole Log

BH03

Project	Project No.	Ground Level (mAOD)	Start Date	Scale
Hayle Inlet WwTW	**UA008501**	**6.26**	**16/05/2016**	**1:50**
Client	Easting (OS mE)	Northing (OS mN)	End Date	
South West Water	**154618.70**	**35772.30**	**16/05/2016**	**Sheet 1 of 1**

SAMPLES		TESTS		DRILL LOG			Water Strikes	PROGRESS		STRATA		Depth (Thickness)	Level	Install/ Backfill
Depth	Type/ No.	Type/ No.	Results	TCR% SCR% RQD%	FI (min ave max)	Flush Rtn%		Date Time	Casing Water	Description	Legend			
0.00 - 0.20	B1							16/05/2016 14:00	0.00 Dry	MADE GROUND: Yellowish light brown very sandy GRAVEL with low cobble content. Gravel is angular to subrounded fine to coarse of concrete, ballast. Cobbles are angular to subrounded of slate and ballast.		(0.20) 0.20	6.06	
0.00 - 0.20	ES1													
0.20 - 0.50	B1											(0.30)		
0.20 - 0.50	ES1											0.50	5.76	
0.50 - 1.00	B1									MADE GROUND: Orange yellowish brown very sandy GRAVEL. Gravel is angular to subrounded fine to coarse of weak mudstone lithorelicts and ballast.				
0.50 - 1.00	ES1											(0.70)		
										MADE GROUND: Light brown very sandy GRAVEL with low cobble content. Gravel is angular to subrounded of ballast and mudstone. Cobbles are angular to subrounded of ballast.				
1.20 - 1.30	NU1	SPT(S)	N>50 (5,8/14,15,15,6 for 25mm)				Dry					1.20	5.06	
1.30 - 1.70	NU1											1.30	4.96	
1.40 - 1.50	ES1									MADE GROUND: Orangish brown sandy angular to subrounded fine to coarse GRAVEL of mudstone.		(0.40)		
1.70 - 2.70	C1	SPT(S)	N>50 (8,17 for 70mm/24,26 for 35mm)	100 8 0		100	Dry			MADE GROUND: Grey locally orange slightly sandy angular to subrounded fine to coarse GRAVEL of mudstone.		1.70 1.80	4.56 4.46	
										Weak to medium strong light grey SLATE. Recovered as non-intact angular to subrounded cobbles. [MYLOR SLATE FORMATION]				
2.70 - 3.70	C1	SPT(C)	N>50 (10,15 for 45mm/38,12 for 25mm)	100 65 60	0 30 100		2.1			Medium strong grey SLATE with frequent gypsum bands. Fractures are subhorizontal very closely to closely spaced stepped smooth. Reduction in strength on fracture surfaces to very weakand orangeish red stained fracture surfaces. [MYLOR SLATE FORMATION]				
										Non intact; Recovered as angular to subrounded coarse GRAVEL.		(3.40)		
3.70 - 5.20	C1	SPT(C)	N>50 (17,8 for 15mm/50 for 70mm)	100 85 85			2.5	16/05/2016 17:00 17/05/2016 08:00	1.70 1.84 1.70 3.50					
								17/05/2016 09:00	1.70 2.00			5.20	1.06	

DRILLING TECHNIQUE			FLUSH DETAILS				WATER OBSERVATIONS						HOLE/CASING DIAMETER				WATER ADDED		
Depth Top	Depth Base	Type	From	To	Rtn %	Flush Type	Date/Time	Strike At	Time Elapsed	Rise To	Casing	Sealed	Hole Dia.	Depth	Casing Dia.	Depth	From	To	Volume (ltr)
0.00	1.20	Inspection Pit	1.70	5.20	100	Water							140	1.70	140	1.70			
1.20	5.20	Rotary Core											116	5.20					

Remarks

Groundwater not encountered prior to the use of water flush. Borehole terminated on Engineer's instruction.

Termination Depth: 5.20m

HCL House
St Mellons
Business Park
Cardiff
CF3 0EY

Unless otherwise stated:
Depth (m), Diameter (mm), Time (hhmm), Thickness (m), Level (mAOD).

Equipment Used

Contractor: **Arcadis Consulting (UK) Ltd**

Logged By: **SC**

Checked By: **PAW**

Photographs

Pro ect				Exploratory Hole ID
Hayle Inlet WwTw				**BH01**
Job No	**Date**	**round Le el (mAOD)**	**Easting (OS)**	**Northing (OS)**
UA008501	18/05/2016	10.71	154613.60	35816.96
Contractor				**Sheet**
				Page 1 of 5

Figure 1

1.20 – 4.20 m

Figure 2

4.20 – 7.00 m

Client	Checker	Appro er
South West Water	CPr	GW

Photographs

Pro ect				Exploratory Hole ID
Hayle Inlet WwTw				**BH01**
Job No	**Date**	**round Le el (mAOD)**	**Easting (OS)**	**Northing (OS)**
UA008501	18/05/2016	10.71	154613.60	35816.96
Contractor				**Sheet**
				Page 2 of 5

Figure 1

7.0 – 9.8 m

Client	Checker	Appro er
South West Water	CPr	GW

Photographs

Pro ect				Exploratory Hole ID
Hayle Inlet WwTw				**BH02**
Job No	**Date**	**round Le el (mAOD)**	**Easting (OS)**	**Northing (OS)**
UA008501	17/05/2016	10.65	154610.10	35808.35
Contractor				**Sheet**
				Page 3 of 5

Figure 1

1.20 – 3.00 m

Figure 2

3.00 – 5.30 m

Client	Checker	Appro er
South West Water	CPr	GW

Photographs

Pro ect				Exploratory Hole ID
Hayle Inlet WwTw				**BH02**
Job No	**Date**	**round Le el (mAOD)**	**Easting (OS)**	**Northing (OS)**
UA008501	17/05/2016	10.65	154610.10	35808.35
Contractor				**Sheet** Page 4 of 5

Figure 1
5.30 – 7.90 m

Client	Checker	Appro er
South West Water	CPr	GW

Photographs

Pro ect				Exploratory Hole ID
Hayle Inlet WwTw				**BH03**
Job No	**Date**	**round Le el (mAOD)**	**Easting (OS)**	**Northing (OS)**	
UA008501	16/05/2016	6.26	154618.70	35772.30	
Contractor				**Sheet**
				Page 5 of 5

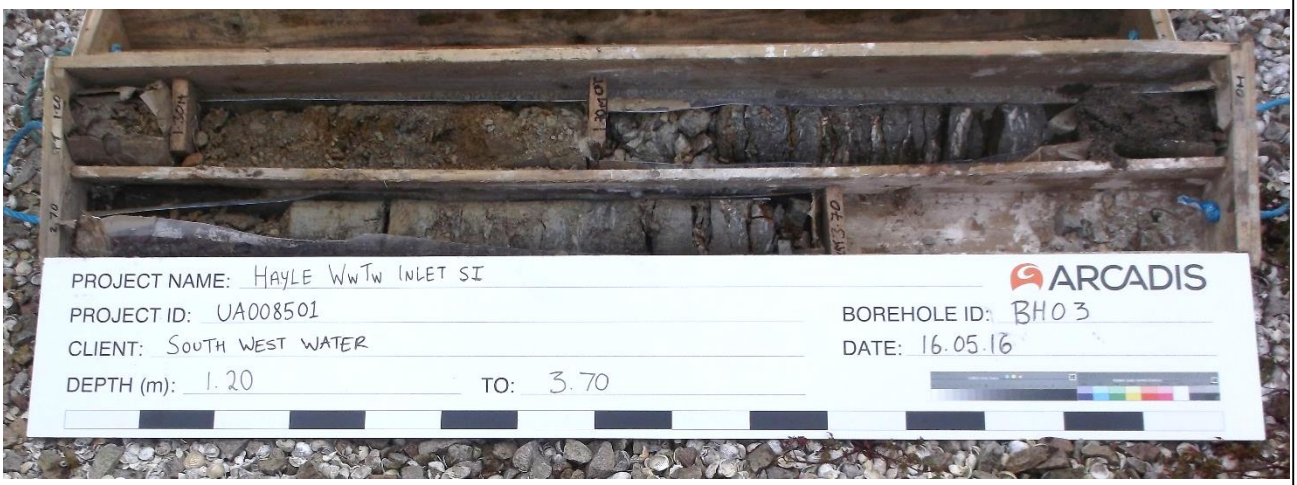


Figure 1

1.20 - 3.70 m

Figure 2

3.70 – 5.20 m

Client	Checker	Appro er
South West Water	CPr	GW

APPENDIX D

CERTIFICATION OF FIELD APPARATUS

SPT Calibration Report

EQUIPE GROUP
www.equipegroup.com

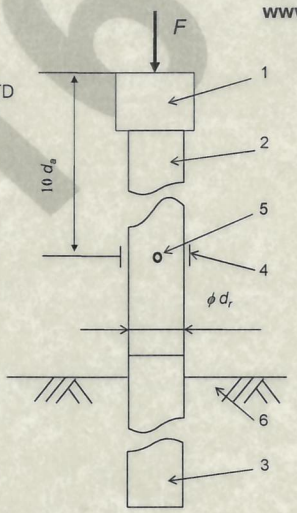
Hammer Energy Measurement Report

Type of Hammer	SPT HAMMER
Client	CC GROUND INVESTIGATIONS LTD
Test No	EQU1454
Test Depth (m)	9.00
Date of Test	19 January 2016
Valid until	18 January 2017
Hammer ID	CC04

Mass of the hammer m = 63.5kg
Falling height h = 0.76m
E_{theor} = $m \times g \times h$ = 473J

Characteristics of the instrumented rod

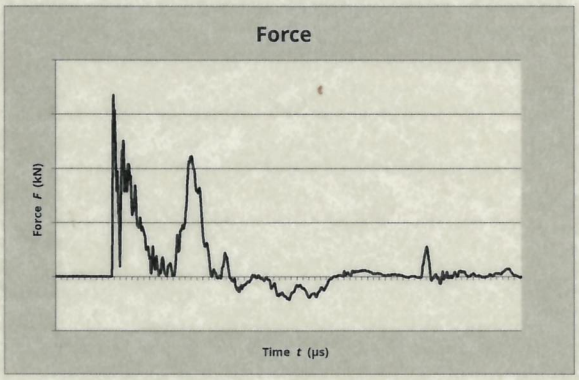
Diameter d_r = 0.052 m
Length of the instrumented rod 0.558 m
Area A = 11.61 cm^2
Modulus E_a = 206843 MPa

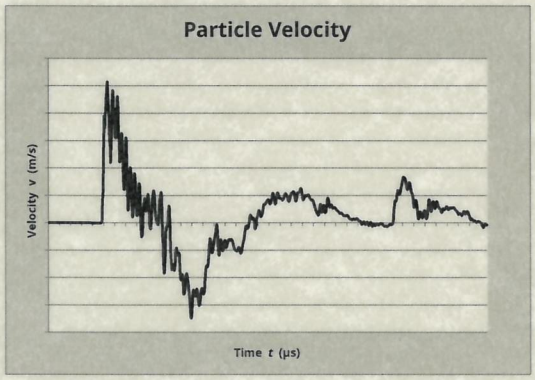


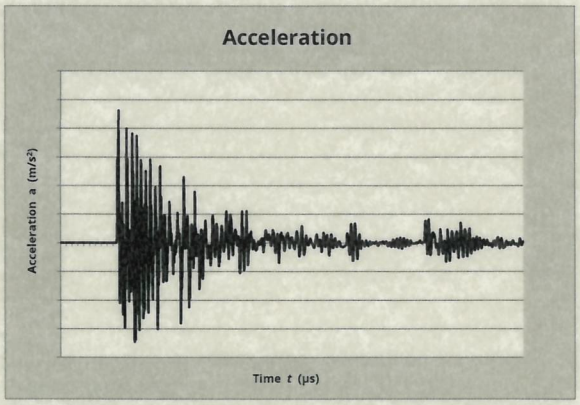
Key
1 Anvil
2 Part of instrumented rod
3 Drive Rod
4 Strain Gauge
5 Accelerometer
6 Ground

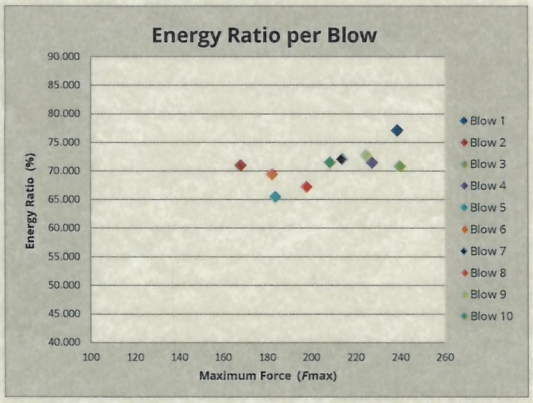
F Force
d_r Diameter of rod

Fig. B.1 and B.2 BS EN ISO 22476-3 : 2005 + A1 : 2011









Observations:
1.

E_{meas} = **0.336** kN-m

E_{theor} = **0.473** kN-m

Energy Ratio (E_r) = $\frac{E_{meas}}{E_{theor}}$ = **71.07%**

Equipe SPT Analyzer Operators: MH

Prepared by: **Checked by:** **Date** 20/01/2016

 Equipe Group, The Paddocks, Home Farm Offices, The Upton Estate, Banbury, Oxfordshire, OX15 6HU
Tel: +44 (0)1295 670990 Fax: +44 (0)1295 678232 Email: info@equipegroup.com

CC Ground Investigations Ltd

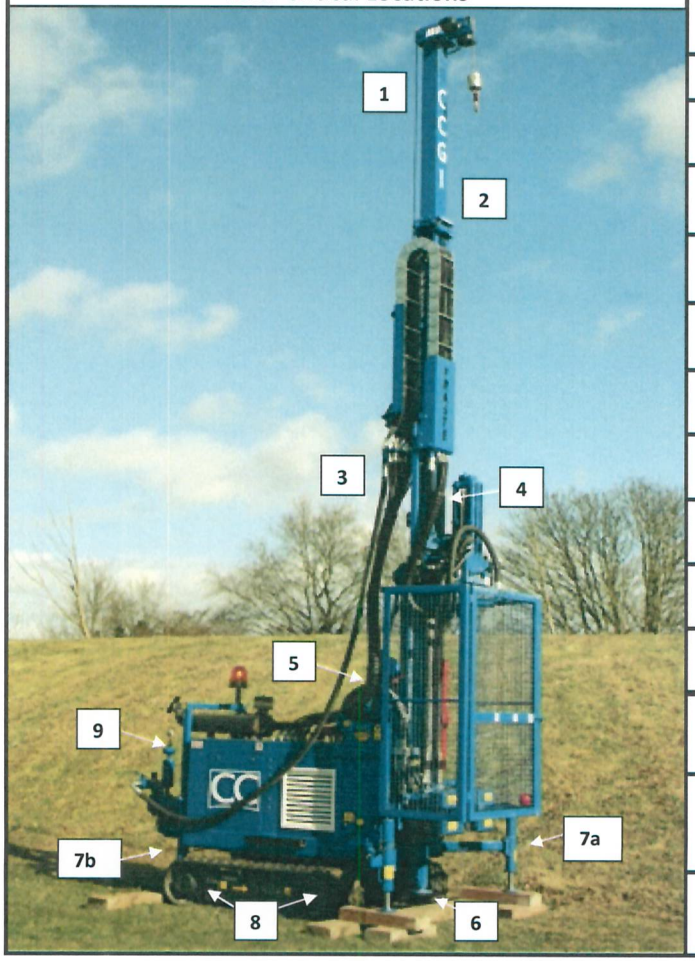
Report of a Thorough Examination of Lifting Equipment

This report complies with the requirements of the Lifting Operations and Lifting Equipment Regulations 1998

Owner of Equipment	**CC Ground Investigations Ltd** Unit A2, Innsworth Technology Park, Innsworth Lane, Gloucester, GL3 1DL	**Tel.**	01452 739165
		Fax	01452 739220
		E-Mail	info@ccground.co.uk

Plant Item:	Fraste Multidrill ML	**Rig ID**	R03	**Serial No.**	M0705158	**Date of Manufacture**	2008

Loler Critical Locations



Location of Examination:	Unit A2, Innsworth Technology Park, Innsworth Lane, Gloucester, GL3 1DL	**Date**	25/09/2015

Item		Safe to Use	Observations & Comments
1	Winch and headgear	Y	Ok. Winch checked with SPT hammer (100kg) load and no creep
2	Mast extension joint	Y	No extension fitted but mast but bolts and rollers ok
3	Mast dump ram	Y	
4	Head drive ram	Y	
	Head drive chain	Y	
5	Mast tilt ram	Y	
6	Casing extractor ram	Y	
7	Legs: Front (7a)	Y	
	Legs: Rear (7b)	Y	
8	Lifting points and bolts	Y	
9	Rig frame	Y	Sheared bolt on cage mounting to be addressed

Date of last examination	10/09/2014	**SWL Critical Changes since last exam? Y/N**	N
Loler Inspector:	**Rupert Garner (Cert No. 15715)**	**NEXT EXAMINATION DUE:**	
Signature:		**25/09/2016**	

CC Ground Investigations Ltd

CC GROUND INVESTIGATIONS LTD

REPORT OF A THOROUGH EXAMINATION OF LIFTING EQUIPMENT

This report complies with requirements of the Lifting Operations and Lifting Equipment Regulations

CC Ground Investigations Ltd

DATE OF THOROUGH EXAMINATION	03/03/2016							
DATE OF REPORT	03/03/2016							
IS THIS THE FIRST EXAMINATION AFTER INSTALLATION OR AFTER ASSEMBLY AT A NEW SITE OR LOCATION?	YES		IF THE ANSWER TO THE QUESTION ON THE LEFT IS YES, HAS THE EQUIPMENT BEEN INSTALLED CORRECTLY?	YES	N/A			
	NO	X		NO	N/A			
WAS THE EXAMINATION FOR AN IN SERVICE 6/12 MONTHLY OR FOR AN EXAMINATION SCHEME OR DUE TO AN EXCEPTIONAL OCCURRENCE?	6 MONTHLY EXAMINATION	X	EXAMINATION SCHEME	X	EXCEPTIONAL OCCURRENCE			
	12 MONTHLY EXAMINATION							

NAME AND ADDRESS OF EMPLOYER FOR WHOM THE THOROUGH EXAMINATION WAS MADE	ADDRESS OF PREMISES AT WHICH THE EXAMINATION WAS MADE	NAME AND ADDRESS OF EMPLOYER OF PERSONS MAKING AND AUTHENTICATING THIS REPORT
CC GROUND INVESTIGATIONS LTD UNIT A2 INNSWORTH TECHNOLOGY PARK, INNSWORTH LANE GLOUCESTER, GL3 1DL	CC GROUND INVESTIGATIONS LTD UNIT A2 INNSWORTH TECHNOLOGY PARK, INNSWORTH LANE GLOUCESTER, GL3 1DL	CC GROUND INVESTIGATIONS LTD UNIT A2 INNSWORTH TECHNOLOGY PARK, INNSWORTH LANE GLOUCESTER, GL3 1DL

DESCRIPTION AND IDENTFICATION OF EQUIPMENT THOROUGHLY EXAMINED	SAFE TO USE	SERIAL No PLANT No. OR BATCH No.	SAFE WORKING LOAD	QTY EXAMINED	DATE OF MANUFACTURE (IF KNOWN)	EXAMINATION TYPE	LATEST DATE FOR NEXT THOROUGH EXAMINATION	NOTES
8mm galv wire 25m F&T one end, thimble on other	Y	LC7305	820kg	1		Visual	03/09/2016	
Screw pin alloy steel bow shackle	Y	APL52	2 ton	1		Visual	03/09/2016	
YassaH07 self locking swivel hook	Y	SH3	2 ton	1		Visual	03/09/2016	
NWY Rod Swivel	Y	PLS40758	2 ton	1		Visual	03/09/2016	
Yellow pin bow shackle	Y	APL6	3.25t	2		Visual	03/09/2016	Used for securing rear of rig on flatbed, not lifting rig

COMMENTS

Driller (Ade Cresswell) has been briefed on what wear and tear to look out for on steel wire rope.

NAME OF PERSON MAKING REPORT	NAME OF PERSON AUTHENTICATING REPORT	SIGNATURE OF AUTHENTICATOR
Rupert Garner	Rupert Garner	

March 20,2014

THE EC DECLARATION OF CONFORMITY IS AVAILABLE.

R03 Original

APPENDIX E

GEOTECHNICAL LABORATORY TEST DATA

Laboratory Report

2788

GEO Site & Testing Services Ltd

Contract Number: 31312

Client's Reference: **UA008501**

Report Date: **20-06-2016**

Client **Arcadis**
Fortran Rd
St Mellons
Cardiff
CF3 0EY

Contract Title: **Hayle Inlet WwTW**

For the attention of: **Sian Carter**

Date Received: **15-06-2016**

Date Commenced: **15-06-2016**

Date Completed: **20-06-2016**

Test Description	Qty
(GI) BRE Suite Total Sulphate, Aqueous Sulphate, Total Sulphur, Aqueous Nitrate, Aqueous Mag, Chloride, 1377 : 1990 Part 3 & BRE CP2/79 - @ Non Accredited Test	9
Disposal of Samples on Project	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

Approved Signatories:
Alex Wynn (Associate Director) - Benjamin Sharp (Contracts Manager) - Emma Sharp (Office Manager)
Jon Tatam (Administrative/Quality Assistant) - Paul Evans (Quality/Technical Manager) - Vaughan Edwards (Managing Director)

GEO Site & Testing Services Ltd
Unit 4, Heol Aur, Dafen Ind Estate, Dafen, Llanelli, Carmarthenshire SA14 8QN
Tel: 01554 784040 Fax: 01554 784041 info@gstl.co.uk gstl.co.uk

Unit 4
Heol Aur
Dafen Ind EstateDafen
Carmarthenshire
SA14 8QN
Tel: 01554 784040
01554 750752
Fax: 01554 770529
01554 784041
Web: www.geo.uk.com

Certificate of Analysis

Date:	17-06-16
Client:	Arcadis
Our Reference:	31312-
Client Reference:	UA008501
Contract Title:	Hayle Inlet WwTW
Description: (Total Samples)	9
Date Started:	15-06-16
Date Completed:	17-06-16
Test Procedures:	(BRE BR 279)
Notes:	

Solid samples will be disposed 1 month and liquids 2 weeks after the date of issue of this test certificate

Approved By:

Authorised Signatories:

Emma Sharp	Ben Sharp	Paul Evans
Laboratory Office Manager	Contracts Manager	Quality Manager

Contract No: 31312-
Client Ref: UA008501
Location: Hayle Inlet WwTW
Date: 17-06-2016

Summary of Chemical Analysis

(BRE BR 279)

Hole Number	Sample Number	Sample Type	Depth m	Sulphate Content as SO_4			Chloride Content		pH Value @ 25°C	Total Sulphur % SO_4	Magnesium g/l	Nitrate NO_3 mg/l
				Acid Soluble Sulphate as % SO_4	Aqueous Extract Sulphate as g/l SO_4	Ground-water g/l	Semi Quantative Test Strip mg Cl/l	Quantative g/l				
				BR 279	BR 279	BR 279	BR 279	BR 279	BR 279	BR 279	BR 279	BR 279
BH01		D	2.20	0.17	0.04		ncp		7.23	0.07	<1	10.00
BH01		C	5.70-6.00	0.14	0.02		ncp		7.75	0.06	<1	10.00
BH01		C	8.80-9.80	0.29	0.05		ncp		8.11	0.11	<1	<10
BH02		B	0.50-1.00	0.21	0.04		ncp		7.33	0.08	<1	<10
BH02		D	3.00-3.45	0.33	0.06		ncp		7.53	0.12	<1	25.00
BH02		C	5.30-6.80	0.22	0.05		ncp		7.70	0.09	<1	10.00
BH02		C	6.80-7.90	0.21	0.05		ncp		7.85	0.09	<1	10.00
BH03		B	0.20-0.50	0.17	0.05		ncp		6.84	0.06	<1	<10
BH03		C	1.70-2.70	0.27	0.05		ncp		7.03	0.10	<1	<10

NCP - No Chloride present

APPENDIX F

GEO-ENVIRONMENTAL LABORATORY TEST DATA

Sian Carter
Arcadis Consulting (UK) Ltd
HCL House
St Mellon's Business Park
Cardiff
CF3 OEY

t: 029 2092 6873

e: Sian.Carter@arcadis.com

i2 Analytical Ltd.
7 Woodshots Meadow,
Croxley Green
Business Park,
Watford,
Herts,
WD18 8YS

t: 01923 225404
f: 01923 237404
e: reception@i2analytical.com

Analytical Report Number : 16-19699

Project / Site name:	Hayle Inlet WwTW	**Samples received on:**	24/05/2016
Your job number:	UA008501	**Samples instructed on:**	09/06/2016
Your order number:		**Analysis completed by:**	17/06/2016
Report Issue Number:	1	**Report issued on:**	17/06/2016
Samples Analysed:	9 soil samples		

Signed:

Rexona Rahman
Reporting Manager
For & on behalf of i2 Analytical Ltd.

Signed:

Emma Winter
Assistant Reporting Manager
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41 -711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils	- 4 weeks from reporting
leachates	- 2 weeks from reporting
waters	- 2 weeks from reporting
asbestos	- 6 months from reporting

Excel copies of reports are only valid when accompanied by this PDF certificate.

Analytical Report Number: 16-19699

Project / Site name: Hayle Inlet WwTW

Lab Sample Number				585606	585607	585608	585609	585610
Sample Reference				BH01	BH01	BH01	BH02	BH02
Sample Number				1	1	1	1	1
Depth (m)				0.50-1.00	2.80-2.90	8.20-8.30	0.50-1.00	1.80-1.90
Date Sampled				18/05/2016	18/05/2016	18/05/2016	17/05/2016	17/05/2016
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	N/A	NONE	15	12	17	11	12
Total mass of sample received	kg	0.001	NONE	1.3	0.90	1.1	1.3	1.1
General Inorganics								
pH	pH Units	N/A	MCERTS	7.7	7.5	7.8	7.7	8.3

Analytical Report Number: 16-19699

Project / Site name: Hayle Inlet WwTW

Lab Sample Number				585611	585612	585613	585614	
Sample Reference				BH02	BH03	BH03	BH03	
Sample Number				1	1	1	1	
Depth (m)				2.70-2.00	0.20-0.50	0.50-1.00	1.40-1.50	
Date Sampled				17/05/2016	16/05/2016	16/05/2016	16/05/2016	
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied	
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**					
Stone Content	%	0.1	NONE	18	< 0.1	< 0.1	< 0.1	
Moisture Content	%	N/A	NONE	11	7.9	7.4	7.3	
Total mass of sample received	kg	0.001	NONE	0.87	1.2	1.4	1.2	
General Inorganics								
pH	pH Units	N/A	MCERTS	7.8	7.9	7.8	8.3	

Analytical Report Number : 16-19699

Project / Site name: Hayle Inlet WwTW

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
585606	BH01	1	0.50-1.00	Brown sandy loam with gravel.
585607	BH01	1	2.80-2.90	Light brown sandy clay.
585608	BH01	1	8.20-8.30	Grey sand.
585609	BH02	1	0.50-1.00	Brown loam and sand with gravel.
585610	BH02	1	1.80-1.90	Grey clay and sand.
585611	BH02	1	2.70-2.00	Light brown sandy clay with stones.
585612	BH03	1	0.20-0.50	Grey loam and clay with gravel.
585613	BH03	1	0.50-1.00	Grey loam and clay with gravel.
585614	BH03	1	1.40-1.50	Grey loam and clay with gravel.

Analytical Report Number : 16-19699

Project / Site name: Hayle Inlet WwTW

Water matrix abbreviations: Surface Water (SW) Potable Water (PW) Ground Water (GW)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Moisture Content	Moisture content, determined gravimetrically.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In-house method based on BS1377 Part 3, 1990, Chemical and Electrochemical Tests	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE

For method numbers ending in 'UK' analysis have been carried out in our laboratory in the United Kingdom.
For method numbers ending in 'PL' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.

Arcadis Consulting (UK) Limited

5th Floor
The Pithay, All Saints Street
Bristol
BS1 2NL
United Kingdom

T: +44 (0)117 372 1200

arcadis.com