Awel y Môr Offshore Wind Farm

Category 6: Environmental Statement

Volume 5, Annex 7.5: Afon Clwyd Trenchless Crossing Works HDD

Date: April 2022

Revision: A

Application Reference: 6.5.7.5

Pursuant to: APFP Regulation 5(2)(a)

REVISION	DATE	STATUS/ REASON FOR ISSUE	AUTHOR:	CHECKED BY:	APPROVED BY:
A	March 2022	ES	SLR	SLR/GoBe	RWE

www.awelymor.cymru

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited
Windmill Hill Business Park
Whitehill Way
Swindon

AFON CLWYD TRENCHLESS CROSSING WORKS (HDD)

Groundwater Risk Assessment

Prepared for: Awel y Môr Offshore Wind Farm Limited

SLR Ref: 406.05356.00009
Version No: 1
February 2022

BASIS OF REPORT

This document has been prepared by SLR with reasonable skill, care and diligence, and taking account of the manpower, timescales and resources devoted to it by agreement with Awel y Môr Offshore Wind Farm Limited (the Client) as part or all of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

SLR shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that SLR and the third party have executed a reliance agreement or collateral warranty.

Information reported herein may be based on the interpretation of public domain data collected by SLR, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in SLR unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.

CONTENTS

DOCUMENT REFERENCES

FIGURES

APPENDICES

1.0 Introduction

This groundwater risk assessment assesses the potential impact of the trenchless crossing works that will be used to install cables beneath the Afon Clwyd as part of the onshore cabling arrangements for Awel y Môr Offshore Wind Farm (AyM OWF).

This report has been prepared in response to feedback received from Natural Resources Wales (NRW) following statutory consultation, under Section 42 of the Planning Act 2008, which ran from 31 August to 11 October 2021. Within its response to statutory consultation NRW requested that a groundwater risk assessment should be completed for each major Horizontal Directional Drilling (HDD) crossing associated with the onshore elements of AyM to ensure that all risks are assessed, and any mitigation measures are outlined and implemented during construction and operation. The Major HDD crossings proposed for the onshore elements of AyM are:

- The crossing at landfall required to pass beneath the North Wales Main Line railway, Robin Hood Bay Caravan Park, Rhyl Golf Club and the proposed East Rhyl Coastal Defence scheme (The Landfall HDD crossing);
- The crossing of the A525;
- The crossing of the Afon Clwyd; and
- The crossing of the A55.

This report provides the groundwater Risk Assessment for the Afon Clwyd HDD. Cabling will be installed beneath the Afon Clwyd using HDD (or other suitable alternative trenchless techniques such as micro-tunnelling). The indicative maximum depth for the HDD would be 20 m below ground level.

Further details on the Project infrastructure, installation methodologies and programme can be found in Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1) of the Environmental Statement (ES).

This report has been informed by the following ES chapters and technical reports:

- Volume 2, Chapter 3: Marine Water and Sediment Quality (application ref: 6.2.3);
- Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1);
- Volume 3, Chapter 5: Onshore Biodiversity and Nature Conservation (application ref: 6.3.5);
- Volume 3, Chapter 6: Ground Conditions and Land Use (application ref: 6.3.6);
- Volume 3, Chapter 7: Hydrology, Hydrogeology and Flood Risk (application ref: 6.3.7);
- Volume 4, Annex 3.1: Water Framework Directive Assessment (application ref: 4.3.1);
- Volume 8, Document 13.1 Outline Code of Construction Practice (application ref: 8.13).

This groundwater risk assessment:

- Describes the existing baseline established from desk studies, dedicated surveys and consultation;
- Outlines the potential environmental effects on groundwater receptors arising from the HDD process including groundwater abstractions, groundwater dependent ecological sites and groundwater fed surface water features;
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental impact.

The effects considered in this chapter include those on the hydrological and hydrogeological receptors that form part of the onshore and coastal environment.

2.0 Study Area, Baseline Data and Methodology

2.1 Study area

The study area for the Afon Clwyd crossing HDD crossing is shown on Figure 1. The HDD works for this location is c.500 m westwards of the A525, which runs past western edge of Rhuddlan. A caravan park is located c.250 m southeast of the proposed crossing, on the southwestern bank of the Afon Clwyd. A sewage treatment works is located immediately eastwards of the trenchless crossing compound on the north-eastern side of the Afon Clwyd.

A buffer zone of 500 m has been considered appropriate for data collection taking into account the nature of the development and likely zone of influence on hydrological and hydrogeological receptors whilst also allowing for refinement in final location and alignments of onshore infrastructure following detailed design (post consent).

2.2 Baseline data

Baseline data with respect to hydrogeology, hydrology and ecology has been taken from publicly available information and opensource data from a range of sources. The data review includes assessing the following:

- Lle Geo-Portal, Welsh Government and Natural Resources Wales (NRW):
    - Main Rivers;
    - Historic and active landfill sites;
    - Statutory and non-statutory environmental designations;
    - Water Framework Directive (WFD) surface water and groundwater classification data; and
    - Groundwater Source Protection Zones (SPZ).
- British Geological Survey (BGS) GeoIndex mapping:
    - Geology – artificial ground, mining, superficial deposits, bedrock;
    - Borehole data; and
    - Aquifer designation and groundwater vulnerability.
- Department for Environment, Food and Rural Affairs (DEFRA) MAGIC website:
    - Statutory and non-statutory environmental designations.
- Cranfield Soil and Agrifood Institute Soilscapes map viewer:
    - Soil type and character.
- North West and North Wales Coastal Group:
    - North West England and North Wales Shoreline Management Plan SMP2; and
    - Denbighshire County Council (DCC): Local Development Plan.

Third party data from bodies such as DCC and NRW has been used to characterise the sensitivity of water features and identify any water dependent designated areas.

Preparation of the groundwater risk assessment has also included data requests and consultation with a number of stakeholders and regulatory bodies that were performed for the production of the Hydrology and Hydrogeology ES chapter. The information and data requested includes:

- NRW - Licenced abstractions, surface water quality, WFD classification data, permitted activities and recorded pollution events.
- DCC - Registered private water supplies in proximity to the onshore Export Cable Corridor (ECC).

2.3 Methodology

This groundwater risk assessment has been developed in accordance with relevant Environment Agency (EA)/NRW guidance on completion of groundwater risk assessments[1] and Hydrogeological Impact Appraisals (HIA)[2] and includes the following stages:

- Section 3 provides a baseline assessment of the site. This includes a summary of the site geology and hydrogeology including information on ground conditions, groundwater levels and flows, groundwater quality and the location of potential receptors which could be impacted as a result of construction activities at the site. In addition, a Conceptual Site Model (CSM) of the current hydrogeological regime is provided.
- Section 4 provides an assessment of the potential impact that the Afon Clwyd HDD works could have upon the identified receptors and regional hydrogeology and hydrology. Appropriate mitigation measures are outlined where required.
- Section 5 provides a summary of the overall impact that the Afon Clwyd HDD works could have upon the local hydrogeology and any identified receptors.

A qualitative risk assessment methodology has been used to assess the potential significance of impact associated with the Afon Clwyd HDD works. Two factors are considered using this approach: the sensitivity of the receiving environment and the magnitude of any potential impact. This approach provides a mechanism for identifying whether additional mitigation measures are potentially required to reduce the risk to groundwater or hydraulically connected surface water receptors.

3.0 Conceptual Site Model

The geological, hydrogeological and hydrological regime in the vicinity of the Afon Clwyd HDD works area is considered under the following headings: location and topography, geological setting and hydrogeological setting, all of which have been used to develop the CSM.

3.1 Site Context

The Afon Clwyd crossing HDD works are c.500 m westwards of the A525, which runs past western edge of the town of Rhuddlan. A caravan park is located c.250 m southeast of the proposed crossing, on the southwestern bank of the Afon Clwyd. A sewage treatment plant is located immediately eastwards of the trenchless crossing compound on the northern side of the Afon Clwyd.

The land extending outwards away from the site in all directions is predominately agricultural, low-lying land with a network of drainage ditches both westwards and eastwards. The corridor of agricultural land is most limited in distance between the site and Rhuddlan; elsewhere it extends for over a kilometre before urban centres are encountered. The coastal towns of Kimmel Bay and Rhyl are first encountered over a kilometre north west and north of the site respectively. Hedgerows and woodland are relatively scarce and typically limited to field boundaries. A site context plan is provided as Figure 1.

---

[1] Natural Resources Wales / Guidance on water discharges

[2] Environment Agency (April 2007) Hydrogeological Impact Appraisal for Dewatering Abstractions, Science Report – SC040020/SR1

3.2 Geology

3.2.1 Soil and Superficial Deposits

The Cranfield Soil and Agrifood Institute Soilscapes online mapping service indicates that loamy and clayey soils of coastal flats with naturally high groundwater are to be expected at the proposed crossing location. These are mapped along the entirety of works for this trenchless crossing to the south of the river. They are also mapped as the most likely soil to be encountered on the northern side of the Afon Clwyd for these crossing works. However, there are freely draining slightly acid sandy soils mapped south-east of the proposed crossing location on the northern side of the Afon Clwyd which may be encountered.

From examination of both the geological map (Geological Survey of Great Britain (1973 and 1985) 1:50,000 Series Solid and Drift Geology Map England and Wales, Sheet 107 – Denbigh, the following deposits are evident.

Superficial deposits across the entirety of the south of the study area south of the Afon Clwyd are mapped as tidal flat deposits of clay, silt and sand.

To the north of the Afon Clwyd tidal flat deposits are mapped to cover the majority of the working area for the HDD and extend northwards. However, there is an outcrop of Devensian glaciofluvial sheet deposits, comprising sand and gravel, bordering upon the proposed trenchless crossing compound associated with this crossing. This extends southwards and is directly adjacent to the Afon Clwyd. East of the sheet deposits, diamicton till deposits are mapped, and extend out towards Rhuddlan, although a corridor of tidal flat deposits c.100-150 m wide continues to border the northern bank of the Afon Clwyd up to the edge of the town.

The sands and tidal flats deposits are underlain by diamicton till which extend across the regional area. These deposits typically consist of boulder clay.

Historic BGS logs within the vicinity of the Afon Clwyd HDD crossing indicate that the superficial deposits are typically c.25 m in thickness and typically consists of sandy silty clays with occasional peat, sand or gravel horizons, which are attributed to the tidal flat deposits, overlying boulder clay of the glacial till.

Several of the logs also record glacial gravels at the base of the till which are shown to directly overlie the sandstone bedrock, although it is noted that these are not recorded in all boreholes, suggesting that the deposits are likely to be laterally and vertically variable.

The superficial geology is presented on Figure 2.

3.2.2 Bedrock

Bedrock at the proposed location for the Afon Clwyd HDD crossing works is mapped by the BGS as the Kinnerton Sandstone Formation. This sandstone formation of dominantly aeolian origin is described as '*typically red-brown to yellow, generally pebble free, fine- to medium grained, and cross-stratified*'.

Historic BGS borehole logs indicate that the sandstone underlying the proposed Afon Clwyd HDD crossing installation is likely to be in excess of 50 m in thickness. With consideration to the depth of sandstone elsewhere in the region a depth of 50 m is considered likely to be an underestimate, and thicknesses of over 100 m may be encountered. The sandstone is indicated by nearby logs to be first encountered at depths approaching at least 25 m below ground level.

The geological setting of the AyM onshore infrastructure and ground conditions is further described within ES Volume 3, Chapter 6: Ground Conditions and Land Use (application ref: 6.3.6).

Bedrock geology is further presented as Figure 3.

3.3 Hydrogeology

3.3.1 Recharge

Met Office Climate Averages (1991-2020) for Rhyl (53.259, -3.509) indicate that the study area has a moderately high average annual rainfall value of 828 mm. Monthly and annual climate averages are provided in table 3-1.

Table 3-1-
Rhyl Climate Averages (1991-2020)

Month	Maximum temperature (°C)	Minimum temperature (°C)	Rainfall (mm)	Days of rainfall ≥1 mm (days)
January	8.05	2.85	74.17	14.50
February	8.39	2.90	61.68	11.83
March	10.14	3.86	52.20	11.14
April	12.63	5.34	49.06	10.27
May	15.62	7.70	52.16	9.77
June	18.16	10.50	60.26	9.60
July	19.84	12.47	62.96	11.17
August	19.50	12.41	68.90	11.83
September	17.48	10.58	72.92	11.10
October	14.17	8.06	89.31	13.57
November	10.83	5.40	88.23	15.97
December	8.57	3.25	96.60	16.17
Annual	13.64	7.13	828.45	146.92

Based on the soils and superficial deposits present beneath the proposed Afon Clwyd HDD route recharge rates are likely to be relatively low. Poorly draining clayey soils are likely to promote a degree of surface water run-off to nearby watercourses and drains.

Freely draining slightly acid sandy soils mapped south of the proposed crossing location on the northern side of the Afon Clwyd would be expected to have relatively high rate of recharge if encountered with incidental rainfall draining to the underlying alluvial deposits recorded in this area.

3.3.2 Hydrogeological Setting

The aquifer characteristics and BGS/NRW aquifer designation of the strata within the immediate vicinity of the works are summarised in Table 3-2-.

Table 3-2-
Aquifer Designations

Deposit Type	Formation	Aquifer Designation
Superficial	Alluvium*	Secondary A
	Glaciofluvial Sheet Deposits	
	Tidal Flat Deposits	Secondary (undifferentiated)
	Diamicton Till	
Bedrock	Kinnerton Sandstone Formation (Triassic)	Principal

Table Note: *Alluvial deposits, although not mapped to be within close proximity to the HDD crossing, are indicated to be present by nearby historic geological logs and are classified as a Secondary A aquifer elsewhere in the local area.

The various classifications are described by the EA as follows:

- Principal Aquifer: layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.
- Secondary A Aquifer: permeable layers that can support local water supplies, and may form an important source of base flow to rivers.
- Secondary B Aquifer: lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin fissures and opening or eroded layers.
- Secondary (undifferentiated): where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value.
- Unproductive Strata: strata that are largely unable to provide usable water supplies and are unlikely to have surface water and wetlands ecosystems dependent on them.

The superficial deposits are all classified as secondary aquifers, however due to the typically clayey nature of the tidal flat and diamicton deposits it is considered that these will typically act as a barrier to significant regional groundwater flow, potentially allowing for a perched aquifer within layers of sand and gravel (where present). Perched water tables are likely to be discontinuous and limited in extent and as such have limited groundwater potential. Shallower perched aquifers potentially provide a limited degree of baseflow to the adjacent watercourses, although this is expected to be of limited significance locally.

The limited extent of mapped sheet deposits directly south of the HDD working area are likely to be more permeable and may potentially provide some baseflow to adjacent watercourses.

Groundwater beneath the study area for this groundwater risk assessment is present within the Principal bedrock aquifer of the Kinnerton Sandstone Formation. It is expected that the sandstone has moderately high transmissivity and groundwater hydraulic conductivity values. It is also likely that groundwater within the sandstone is confined by the overlying clayey deposits.

BGS borehole logs to the north and south of the crossing (SJ07NW13 and SJ07NW108) indicate that groundwater was typically struck at the base of the superficial deposits at c.30 m below ground level and rebounded to between 0.15 m and 2 m below ground level, confirming that the superficial deposits are confining the underlying sandstone.

Where the sandstone bedrock is directly overlain by glacial gravels in the base of the superficial deposits, groundwater is expected to rise into these deposits which will therefore be in continuity with the underlying bedrock.

The Kinnerton Sandstone Formation forms part of the Clwyd Permo-Triassic Sandstone WFD groundwater body.

3.3.3 Abstractions

NRW have indicated that there are two licensed abstractions located within a 2 km radius of the Afon Clwyd crossing HDD works.

A surface water abstraction used for spray irrigation is located c.1.75 km westwards of the works, and a borehole is located c.700 m north. Further details are provided below in Table 3-3.

Table 3-3-
Licensed Abstractions

Abstraction Type	National Grid Reference	License No.	Usage	Source
Borehole	SJ 01330 79500	24/66/7/0029	General Farming & Domestic	Groundwater - Undefined
Surface Water	SH 99680 78890	24/66/7/0036	Spray Irrigation - Direct	Surface Water

A Corresponding BGS borehole log in the location of the abstraction borehole (SJ07NW13) confirms that this borehole abstracts from the sandstone bedrock.

DCC have indicated that there are no private water supplies within a 500 m radius of the crossing.

No groundwater Source Protection Zones (SPZs) are noted within the study area.

3.4 Hydrology

The hydrology of the study area is presented on Figure 4.

HDD will go beneath the Afon Clwyd and the Clwyd North and South Embankment Drains which are outlined in further detail below. The Afon Clwyd, Clwyd Embankment Drains and associated tributaries are underlain by tidal flat deposits. Borehole logs confirm that these comprise typically comprise of clays which will have little potential for groundwater baseflow.

3.4.1 Afon Clwyd

The Afon Clwyd is a main river and is the most significant watercourse within the study area, with an upstream catchment of over 700 km^2 upstream of the point of the HDD crossing. The catchment drains large areas of north Denbighshire, including the settlements of St Asaph, Denbigh and Ruthin; the Afon Elwy sub-catchment, which drains areas to the east of Conwy County; and the Afon Chwiler sub-catchment, which drains land to the west of Flintshire.

3.4.2 Clwyd Embankment Drain North and South

These are drainage channels to the northeast and southwest of the Afon Clwyd channel and which operate as collector drains on the landward side of respective flood defences serving the Afon Clwyd. The drains both flow to the northwest, parallel to the Afon Clwyd, and ultimately discharge into the Afon Clwyd downstream (Clwyd Embankment Drain North via Rhyl Cut and Clwyd Embankment Drain South via the Afon Gele).

3.4.3 Non-main river watercourses

There are a number of existing field drains, ditches and irrigation channels within the study area for the proposed HDD works, particularly to the north and west. The majority of these are field drains which connect to the Clwyd Embankment Drain. These features are detailed in Figure 4.

3.4.4 Water Quality

Surface water quality is measured as part of the WFD classifications for main rivers. The WFD Cycle 2 (2018 Interim) Status of waterbody catchments within the study area for the onshore elements of AyM are presented in Table 3-4.

The HDD working area on the northern side of the Afon Clwyd HDD falls within Glanfyddion Cut WFD Cycle 2 (2018 Interim) river waterbody area. The southern side falls within the Afon Gele WFD Cycle 2 (2018 Interim) river waterbody area.

Table 3-4-
WFD Cycle 2 (2018 Interim) River Waterbody Catchment Statuses

River Waterbody Catchment	WFD Cycle 2 (2018 Interim) Status		
	Ecological	Chemical	Overall
Afon Gele	Moderate	Good	Moderate
Glanffyddion Cut	Moderate	Good	Moderate

The Afon Clwyd crossing HDD works are located within the Clwyd Permo-Triassic Sandstone WFD groundwater unit. This was assessed in 2015 as having a good overall, quantitative and chemical status.

There are no recorded 'significant' pollution incidents within the study area.

3.5 Ecologically Designated sites

As presented on Figure 4 the HDD crossing is located partially within the Clwyd Estuary and Adjacent Fields LWS.

The Clwyd Estuary and Adjacent Fields LWS encompasses the river and network of drains associated with the Afon Clwyd and Clwyd Embankment Drain North, considered in Section 3.4. As discussed, these watercourses are all located on low permeability superficial deposits and is area not judged to be in significant hydraulic connection with groundwater underlying the proposed HDD works.

3.6 Conceptual Site Model Summary

The assessment of the baseline conditions of the Afon Clwyd HDD Crossing Works indicate that the proposed crossing area is underlain by the Principal aquifer associated with the Kinnerton Sandstone Formation, which has the potential to provide significant groundwater flows for abstractions.

The sandstone bedrock is overlain by approximately 25 m of superficial tidal flat and glacial till which consist primarily of low permeability clays and confine the underlying sandstone aquifer. Several borehole logs suggest the presence of glacial gravels at the base of the till which would likely be in hydraulic continuity with the underlying sandstone aquifer.

The proposed HDD works will drill to a maximum depth of 20 m below ground level, and due to uncertainty with the exact depth of overlying superficial deposits, there is therefore the potential, although limited, that the drilling will encounter either the Kinnerton sandstone aquifer directly or overlying gravels.

The superficial deposits have the potential for limited groundwater flow within any sandy and gravelly horizons, however these tend to be variable and unconnected and are therefore unlikely to provide significant flows for either abstractions or surface water baseflow.

Furthermore, due to the likely depth of the sandstone it is very unlikely groundwater associated with this aquifer provides baseflow to the Afon Clwyd or nearby watercourses in the vicinity of the proposed HDD.

A groundwater abstraction has been identified, approximately 700 m north of the proposed works, which is likely to be abstracting groundwater from the Kinnerton Sandstone Formation aquifer and is therefore a potential receptor.

No groundwater dependent ecological sites have been identified within proximity of the Afon Clwyd HDD crossing works.

4.0 Hydrogeological and Hydrological Impact Assessment

A description of the proposed HDD activity at the Afon Clwyd crossing location is provided in the ES, Volume 3, Chapter 1: Onshore Project Description (application ref: 6.3.1).

The potential impact of the proposed HDD trenchless crossing on groundwater receptors are outlined below using qualitative risk assessment methodology based on the sensitivity of the receptor and likelihood of impact occurring. Impacts assessed as moderate or high are considered to require further assessment or mitigation.

4.1.1 Potential Effects

Without appropriate design and controls, construction works have the potential to impair the local hydrology (water quality) and hydrogeology (groundwater levels, flow and quality), from the following:

- The use of machinery and the movement of soils has the potential to generate suspended solids in run-off and/ or introduce oils or hydrocarbons to the water environment;
- The use of bentonite drilling muds has the potential to impact on water quality;
- Existing groundwater flow paths could be disturbed or altered, impacting nearby groundwater abstractions.

Standard construction techniques and best practices will be used to avoid or reduce these potential impacts with outline control measures set out in the Outline Code of Construction Practice (CoCP) (application ref: 8.13). Details are given in the following section.

4.1.2 Receptor Sensitivity

Based on the review of the baseline conditions and the CSM as developed in the previous section it is considered that the primary receptor in the vicinity of the development site is the underlying Principal bedrock aquifer. The superficial deposits are also considered a potential receptor, however given the limited groundwater potential these are not considered to be highly sensitive as there are no associated abstractions and are unlikely to provide significant flow to either surface water or ecological receptors.

For the purpose of this assessment the sensitivity of the bedrock aquifer is assessed as High whilst the superficial deposits are assessed as Low.

No groundwater abstractions have been recorded within 500 m of the site, however the licensed abstraction 700 m to the north has been assessed as worst case.

4.1.3 Embedded mitigation

As part of the design for the onshore works careful routing of the onshore ECC and design of key crossing points (sea defence structures, main rivers, non-main and ordinary watercourses, roads) has been undertaken to avoid key areas of sensitivity.

Best practice construction techniques and procedures will be followed during any works and these are outlined within the outline CoCP and accompanying appendices that provide a series of management plans which will be agreed with NRW and DCC prior to any development taking place. These include:

- A Pollution Prevention and Emergency Incident Response Plan (PPEIRP) is being developed for the works, an outline version of which is provided in the outline CoCP Appendix 6: Pollution Prevention and Emergency Incident Response Plan (application ref 8.13.6) that sets out the principles to be followed when the final PPEIRP is finalised. The outline PPEIRP sets out the pollution prevention measures, and emergency incident responses, which may be implemented by the Applicant and its contractors during construction;
- An Outline Soil Management Plan (SMP) is provided as Appendix 4 to the outline CoCP (application ref: 8.13.4). The SMP provides details of mitigation measures and best practice handling techniques to safeguard soil resources by ensuring their protection, conservation and appropriate reinstatement during the construction of the onshore works. These measures will include guidance on earthworks and stockpiling in order to minimise potential entrainment of sediments to surface water features or increase in nitrogen loading to groundwater through infiltration.

The construction works will also be undertaken in accordance with good practice guidance within the following documents:

- CIRIA SP156 Control of Water Pollution from Construction Sites – Guide to Good Practice, 2002;
- CIRIA C502 Environmental Good Practice on Site C741, CIRIA 2015;

The Pollution Prevention Guidelines (PPGs) (which are progressively being replaced with Guidance for Pollution Prevention (GPPs)) provide environmental good practice for the whole of the UK and environmental regulatory guidance for Wales. Relevant PPGs/GPPs will be followed, including:

- GPP01: Understanding your environmental responsibilities – good environmental practices (Oct 2020)
- GPP02: Above Ground Oil Storage Tanks (Jan 2018);
- GPP04: Treatment and Disposal of wastewater where there is no connection to the public sewer (Nov 2017);
- PPG6: Working at construction and demolition sites (2012);
- GPP08: Safe storage and disposal of used oils (July 2017);
- GPP13: Vehicle Washing and Cleansing (April 2017);
- PPG18: Managing fire water and major spillages (June 2000);
- GPP21: Pollution incident response planning (June 2021);
- GPP22: Dealing with Spills (Oct 2018).

4.1.4 Impact on groundwater quality from construction activities

Measures outlined within the outline CoCP, SMP and PPEIRP will minimise the potential for any contaminants to be generated or released as part of the works and therefore minimise the potential impact on water quality.

The embedded mitigation measures include the implementation of spill procedures and use of spill kits. These measures together with appropriate drainage systems and containment will minimise the potential for any reduction in water quality associated with spills or leaks of stored oils/ fuels/ chemicals or other polluting substances migrating into nearby groundwater.

Whilst there is the potential for the construction of an entry/ exit pit relating to the HDD cable installation to introduce a pathway for contaminants, the low permeability of the underlying strata is likely to limit the migration of potential contaminants.

In the event that groundwater within the Kinnerton Sandstone is encountered this could be sensitive to accidental spillages and runoff from the HDD works as the drilling will create a preferential pathway to the underlying sandstone. Measures in the outline CoCP to control the storage and use of materials and chemicals would be implemented, which would limit the magnitude of impact.

The above embedded mitigation measures will ensure that the risk to both shallow perched groundwater within the superficial deposits and groundwater within the deeper Kinnerton Sandstone aquifer is low.

4.1.5 Impact on groundwater quality from drilling mud

Drilling mud is used as part of the HDD process and is pumped into the works to stabilise the drilled bore, recover drilling cuttings and ensure it does not collapse. Bentonite is the most commonly used drilling mud.

Bentonite is a naturally occurring swelling clay with sodium bentonite and calcium bentonite the most widely used in industry. The primary water quality concerns from the use of bentonite drilling muds are related to increased turbidity of the aquifer, or the release of elevated pH, sodium or calcium concentrations.

Bentonite clays have very fine particle sizes which in certain conditions, such as within fissured aquifers, has the potential to migrate from the drilling hole where voids in the aquifer are connected via the drilling. Drilling will however primarily take place through the superficial tidal flats, alluvial and till deposits which are dominated by clays and silts which will limit the potential for any migration of bentonite away from the drill hole.

The Kinnerton Sandstone is described as a *'fine to medium grained sandstone',* and therefore the potential for significant migration of bentonite drilling muds is considered to be very low. Any impact to water quality would therefore be highly localised to the immediate vicinity of the drilling works, as outlined above there are no sensitive abstractions or ecological sites within the immediate vicinity of the works which could be impacted. Given the significant aquifer thickness in comparison to the small diameter of the open hole and the small volume of bentonite used in the process the potential for the bentonite to adversely impact water quality is considered to be very low.

It should also be noted that the use of bentonite as a drilling mud is a common approach in borehole drilling (both HDD and conventional well drilling) and is generally considered to be low risk to groundwaters. Good management and disposal practices of excess bentonite will apply to ensure further protection to superficial and bedrock aquifers.

The above assessment therefore indicates that the risk from the use of drilling muds is low. To ensure that the risk is controlled careful monitoring of the drilling mud used will be undertaken to ensure that any losses to the aquifer which could indicate migration away from the drill hole are identified as early as possible and allow for appropriate mitigation to be put into place in the highly unlikely event of this occurring.

4.1.6 Impact on surface water quality

The CSM indicates that the watercourses within the vicinity of the proposed crossing are considered to receive very little or no groundwater baseflow due to the typically low permeability of the superficial deposits, therefore it is considered highly unlikely that any impact from the HDD works would migrate to surface water. This along with the measures outlined above to protect groundwater will ensure that the potential impact on surface water quality is negligible.

4.1.7 Impact on Groundwater Levels and Flows

As outlined in Section 3.3, confined groundwater is considered to potentially be present within the underlying bedrock, although this is at depth. There is some limited potential that the HDD crossing will encounter groundwater from the underling bedrock aquifer where this is in continuity with gravels and sands at the base of the overlying superficial deposits.

Some perched groundwater is potentially present within the superficial deposits, notably higher permeability sands and gravels, however given their typical low permeability these are unlikely to provide a significant resource.

The method of working will minimise the size of the opening and therefore ensure that any dewatering which does occur as a result of the tunnelling is kept to a minimum. This could have a moderate impact on any groundwater encountered within the superficial deposits as it will likely locally alter the flows however given the lack of any associated receptors and the low sensitivity of the aquifer the magnitude of impact is considered to be low and acceptable.

In the unlikely event that the HDD works encounter the bedrock aquifer, or connected glacial gravels, the overall impact on flows is likely to be low owing to the very small size of the opening in relation to the significant aquifer thickness (expected to be significantly in excess of 50m) and the lack of any nearby significant receptors which could be impacted by what would be a very localised radius of influence. Following installation, the presence of the cables within the aquifer will potentially result in a very minor alteration in flows but given the minor development extent in relation to the aquifer the overall significance of impact is assessed as minor and no further mitigation above that embedded in the design is considered necessary.

4.1.8 Impact on Groundwater Abstractions

There are no groundwater abstractions within 500 m of the proposed HDD crossing. Given the limited potential for interaction with the bedrock groundwater and the pollution prevention measures which will be put into place, the potential for adversely impacting abstractions further afield is assessed as very low.

The release of bentonite into the aquifer has the potential to impact the turbidity of drinking water, however given the distance of abstractions from the HDD works (700 m +) and the low likelihood of bentonite having a pathway to migrate into the sandstone aquifer, there is considered to be a very low risk to abstractions.

5.0 Conclusions

A groundwater risk assessment has been undertaken to assess the potential impact of the proposed Afon Clwyd HDD Crossing Works on groundwater receptors.

The assessment has indicated that the primary potential receptor of concern relates to groundwater within the underlying Kinnerton sandstone aquifer.

The various watercourses in the vicinity of the development area are not considered to be groundwater dependent due to the low permeability of the overlying superficial deposits which act as a confining layer above the sandstone aquifer.

An assessment of the potential impact of the works on groundwater levels, flow and quality and surface water quality has been undertaken and confirms that the potential impact on levels and flows is considered to be negligible or low. The risk to both groundwater and surface water quality will be managed through the implementation of best practice measures in accordance with a series of management plans developed for the works and ensure that the risk to groundwater quality is low. The lack of any hydraulic continuity between groundwater and surface water, notably the Afon Clwyd and associated tributaries/ drains, ensures that the risk to surface water quality is negligible. Similarly, the risk to abstractions further afield from the study area is considered very low.

6.0 References

ArcGIS (n.d.) WFD Cycle 2 (2018 Interim) Rivers and water-bodies in Wales. [online] Available at: [redacted] [Accessed 31 Jan. 2022].

British Geological Survey (n.d.) GeoIndex (onshore). [online] Available at: [redacted] Accessed 31 Jan. 2022].

CIRIA (2002) Control of Water Pollution from Construction Sites: Guide to Good Practice.

CIRIA (2015) Environmental Good Practice on Site C741.

Earthwise: BGS (n.d.) Hydrogeology of Wales: Permo-Triassic and Jurassic aquifers - Vale of Clwyd. [online] Available at: [redacted] [Accessed 31 Jan. 2022].

Environment Agency (2007) Hydrogeological impact appraisal for dewatering abstractions. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291080/scho0407bmae-ee.pdf [Accessed 31 Jan. 2022].

Innogy (2020). Awel y Môr Offshore Wind Farm Environmental Impact Assessment Scoping Report

Institute of Geological Sciences (1989) Hydrogeological map of Clwyd and Cheshire Basin. [online] Available at: [redacted] [Accessed 25 Jan. 2022]. Contains British Geological Survey materials © UKRI [1989]"

Lle (n.d.) A Geo-Portal for Wales. [online] Available at: https://lle.gov.wales/home [Accessed 31 Jan. 2022].

Met Office (n.d) UK Climate Averages [online] Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/ukclimate-averages [Accessed 31 Jan. 2022].

National Soil Resources Institute: Cranfield University (n.d.) Soilscapes Soil Types Viewer [online] Available at: [redacted] [Accessed 31 Jan. 2022].

Natural Resources Wales (2004). Development Advice Map.

Natural Resources Wales (2015). Western Wales River Basin Management Plan.

Natural Resources Wales (n.d.) Bathing Waters Overview [online] Available at: https://environment.data.gov.uk/wales/bathing-waters/profiles/index.html [Accessed 31 Jan. 2022].

Natural Resources Wales (n.d.) Interactive Map Viewer [online] Available at: https://maps.cyfoethnaturiolcymru.gov.uk/Html5Viewer210/Index.html?configBase=https://maps.cyfoethnaturiolcymru.gov.uk/Geocortex/Essentials/REST/sites/External_Map_Browser/viewers/EMB_Address/virtualdirectory/Resources/Config/Default&locale=en-gb [Accessed 31 Jan. 2022].

Natural Resources Wales (n.d.) River Basin Management Plans 2015 - 2021 [online] Available at: [redacted] Accessed 31 Jan. 2022].

Natural Resources Wales (n.d.) Water Watch Wales Map Gallery [online] Available at: https://waterwatchwales.naturalresourceswales.gov.uk/en/ [Accessed 31 Jan. 2022].

NetRegs (n.d.) Guidance for Pollution Prevention (GPPs). [online] Available at: [redacted] [Accessed 31 Jan. 2022].

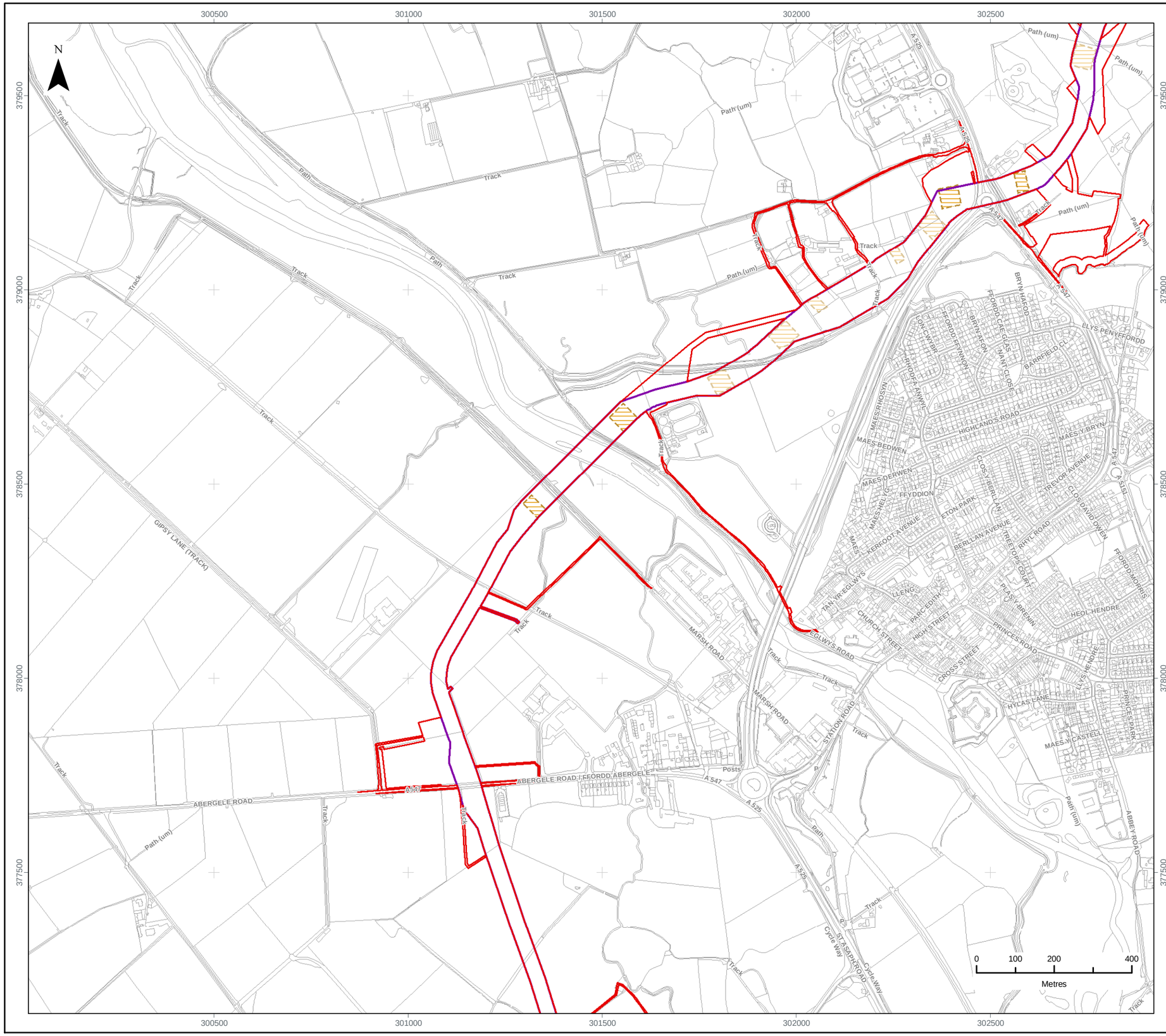
UK Government (Last updated 2 May 2019) Pollution prevention for businesses. [online] GOV.UK. Available at: https://www.gov.uk/guidance/pollution-prevention-for-businesses/ [Accessed 31 Jan. 2022].

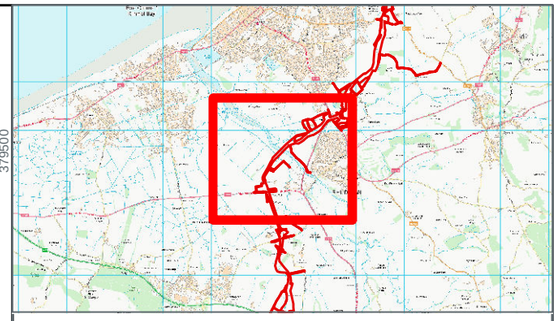
UK Government (Last updated 3 April 2018) Groundwater risk assessment for your environmental permit. [online] Available at: https://www.gov.uk/guidance/groundwater-risk-assessment-for-your-environmental-permit [Accessed 31 Jan. 2022].

UK Government National Archives (n.d.) Pollution prevention advice and guidance (PPG) [online] Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20140328090931/http://www.environment-agency.gov.uk/business/topics/pollution/39083.aspx [Accessed 31 Jan. 2022].

Welsh Assembly Government (2004). Technical Advice Note 15: Development and Flood Risk.

Welsh Government (2021). Planning Policy Wales Edition 11.





LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Data Source:
© Crown copyright [and database rights] (2022) OS OpenData.

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

Afon Clwyd Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

SITE CONTEXT

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

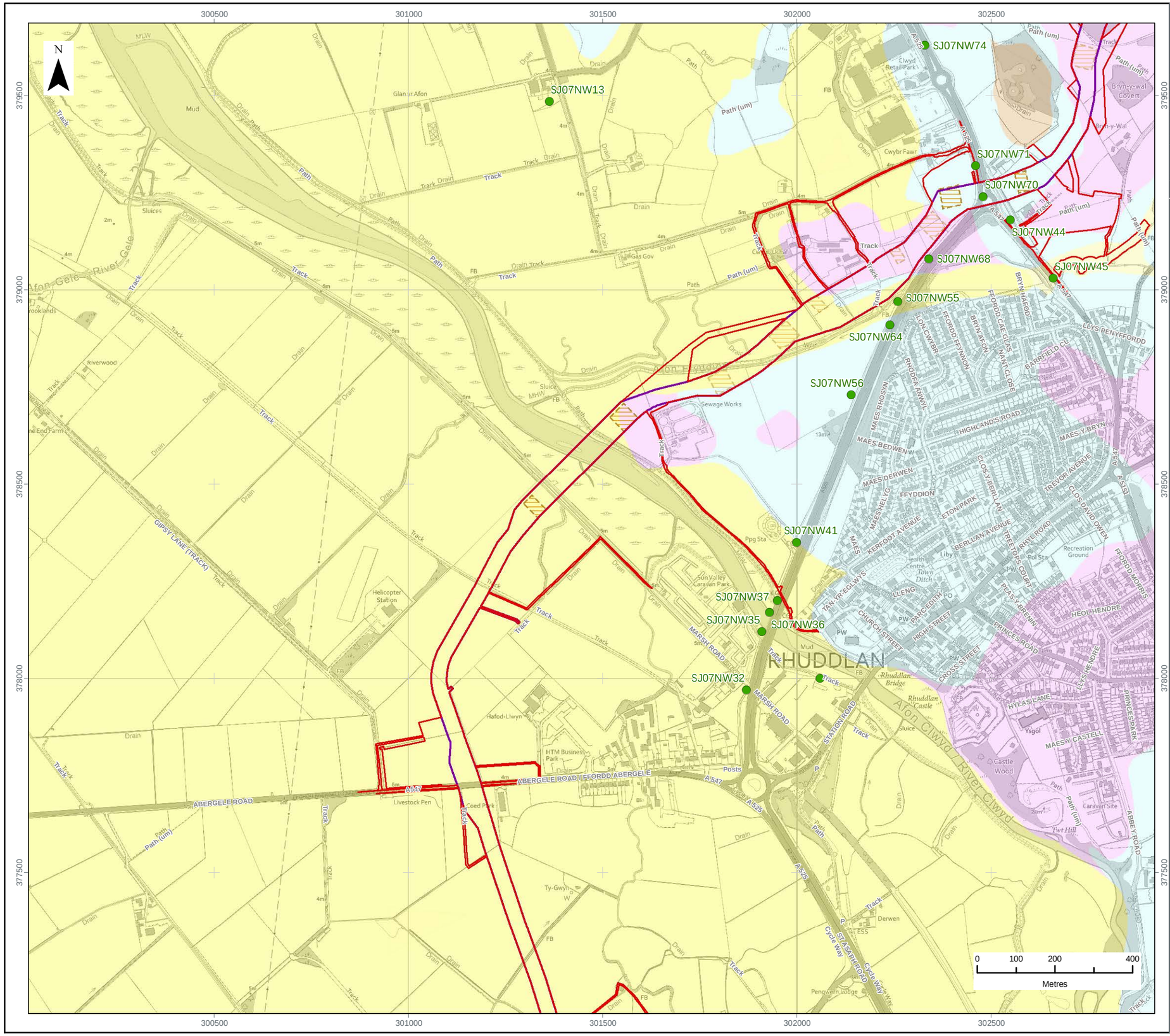
FIGURE NUMBER:

FIGURE 1

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

P:\05356 - GoBe Consultants Ltd\00009 Awel y Mor\Tech\GIS\Dwgs\Wking\202201 HRA\05356.00009.0294.0 HDD Site Context.mxd



LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Superficial Geology

- Tidal Flat Deposits - Clay, Silt And Sand
- Till, Devensian - Diamicton
- Glaciofluvial Sheet Deposits, Devensian - Sand And Gravel
- Lacustrine Deposits - Clay And Silt
- Historic BGS Borehole

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

Afon Clwyd Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

SUPERFICIAL DEPOSITS

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

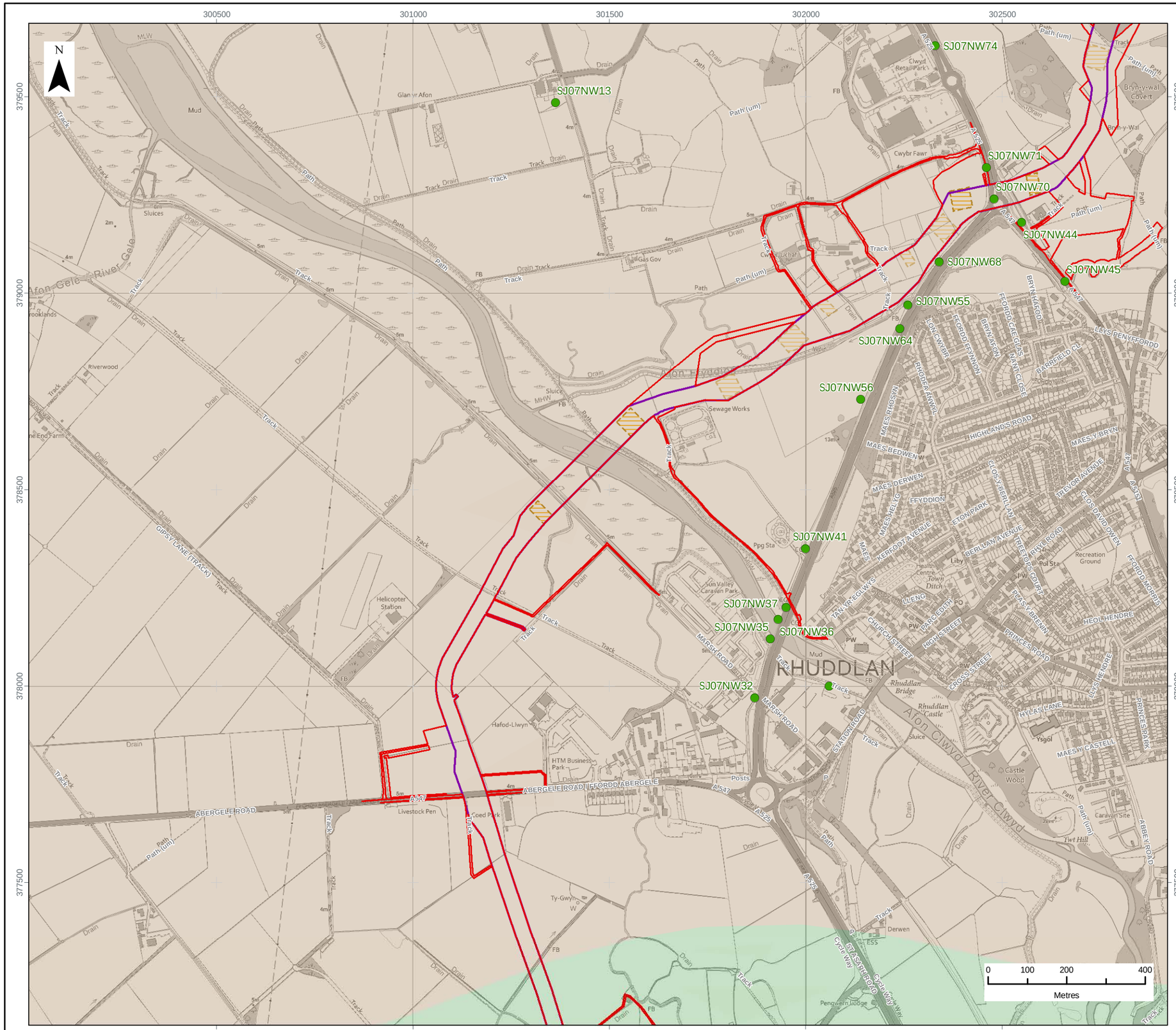
FIGURE NUMBER:

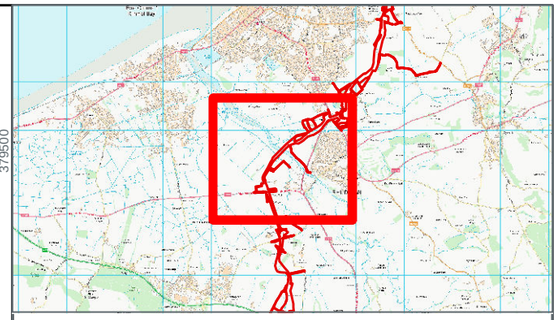
FIGURE 2

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

P:\05356 - GoBe Consultants Ltd\00009 Awel y Mor\Tech\GIS\Dwgs\Wking\202201 HRA\05356.00009.0295.0 HDD Superficial Deposits.mxd





LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound

Bedrock Geology

- Kinnerton Sandstone Formation - Sandstone (Triassic)
- Warwickshire Group - Mudstone, Siltstone And Sandstone (Carboniferous-Permian)
- Historic BGS Borehole

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

Afon Clwyd Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

BEDROCK GEOLOGY

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

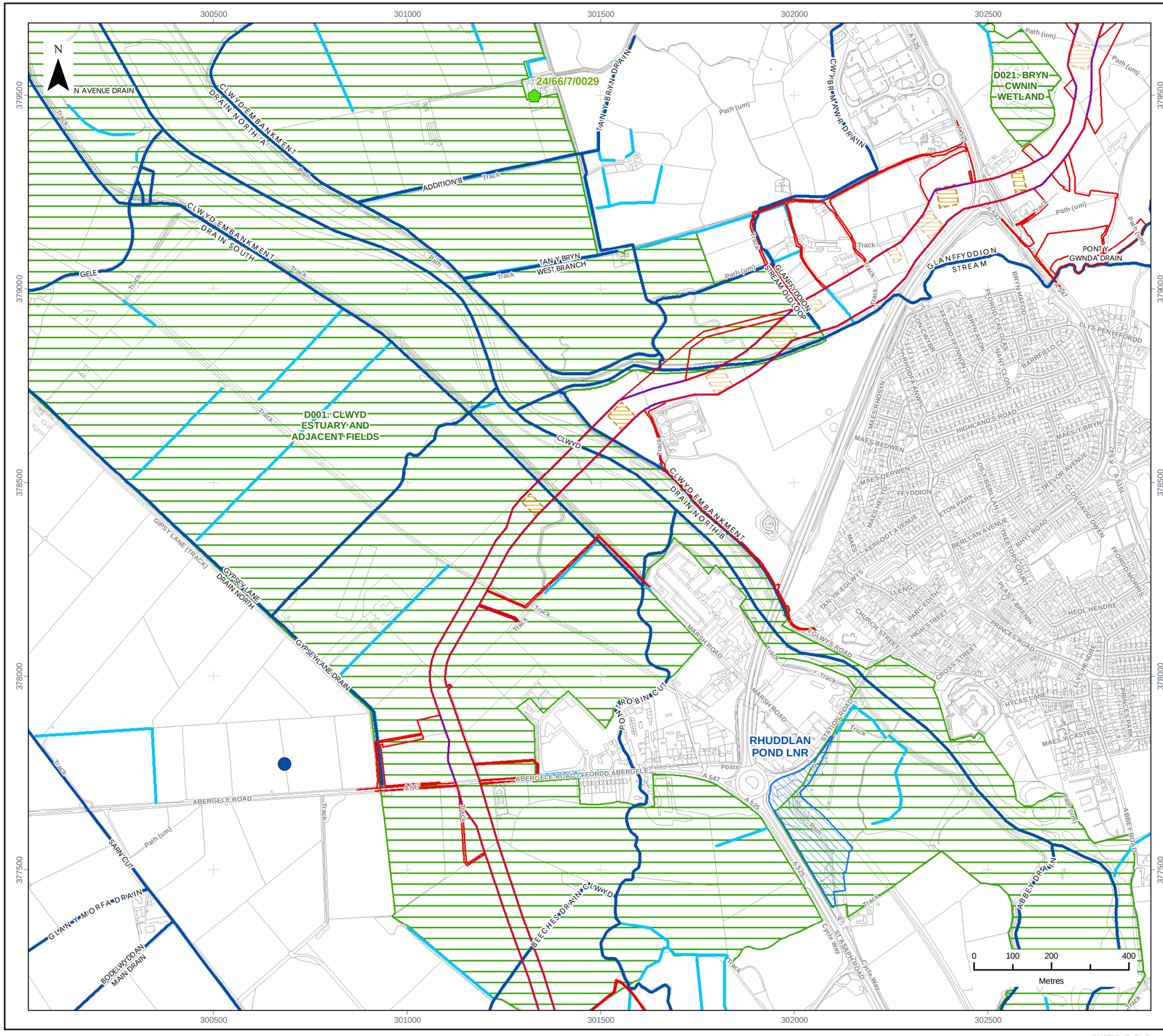
FIGURE NUMBER:

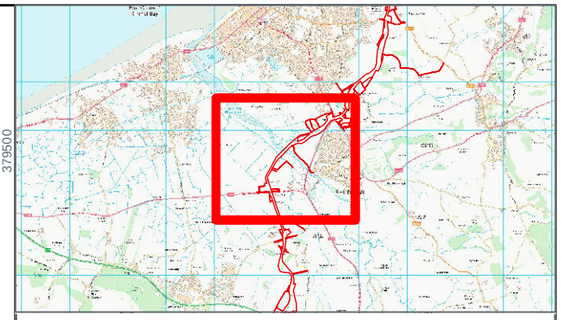
FIGURE 3

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

P:\05356 - GoBe Consultants Ltd\00009 Awel y Mor\Tech\GIS\Dwgs\Wking\202201 HRA\05356.00009.0296.0 HDD Bedrock Geology.mxd





LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Trenchless Crossing Compound
- Local Nature Reserve (LNR)
- Local Wildlife Site
- NRW Main River
- Ordinary Watercourse
- Licensed Groundwater Abstractions
- Private Water Abstraction

Note: There are no Source Protection Zones within the Displayed Area

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

Afon Clwyd Trenchless Crossing Works (HDD):
Hydrogeological Risk Assessment

FIGURE TITLE:

GROUNDWATER SPZs, WATERCOURSES, ABSTRACTIONS AND ECOLOGICAL SITES

VER	DATE	REMARKS	Drawn	Checked
1	08/02/2022	First Issue	PW	SM

FIGURE NUMBER:

FIGURE 4

SCALE:	PLOT SIZE:	DATUM:	COORDINATE SYSTEM:
1:10,000	A3	ODN	British National Grid

Fferm Wynt Alltraeth
AWEL Y MÔR
Offshore Wind Farm

P:\05356 - GoBe Consultants Ltd\00009 Awel y Mor\Tech\GIS\Dwgs\Wking\202201 HRA\05356.00009.0297.0 HDD Groundwater SPZ.mxd

BGS BOREHOLE REFERENCE: SJ07NW32

Easting: 301870
Northing: 377970
Date: 1992
Length: 27.50m

Norwest Holst Soil Engineering Ltd.

Borehole No. 12

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 250/200mm
0187, 7797 SJ 07 NW 32
Sheet 1 of 3
Co-ords 9841E 20175N
Ground Level 4.58 m.A.O.D.
Date 4/3/92 - 11/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL: Soft brown sandy silty clay with occasional gravel. Rootlets.		0.30	4.28		0.00		
		0.60	3.98	0.00	0.30 0.50-1.00	U(38)*	
Stiff grey mottled brown silty CLAY with very occasional fine gravel. Occasional rootlets. (Alluvium)		0.70	3.88		0.50 0.60 0.70		
0.50-0.60m: firm to stiff and with occasional small marine shells.		1.50	3.08	0.00	1.00-1.50	U(42)	
		1.90	2.68		1.50 1.90		
Stiff reddish brown mottled grey slightly sandy silty CLAY with occasional gravel. Occasional rootlets. (Alluvium)		2.80	1.78	1.50	2.00-2.80 2.80	P (0.70m rec)	
Soft to firm grey mottled brown silty CLAY, very occasional shell fragments. (Alluvium)				3.00	3.00-3.80	P (0.70m rec)	
Firm brown mottled grey silty CLAY. (Alluvium)					3.80		
Soft grey and brown silty CLAY. (Alluvium)				3.00	4.00-4.80	P (0.80m rec)	
Brown fibrous PEAT, slightly clayey in parts. (Alluvium)		4.80	-0.22		4.80		
Very soft to soft grey peaty silty CLAY. (Alluvium)				4.50	5.00-5.80	P (0.80m rec)	
					5.80 6.00		
				6.00	6.00-6.80	P*	
		6.70	-2.12		6.50 6.70		4/3
Soft grey very sandy silty CLAY with bands of clayey silty fine sand and very occasional gravel. (Terrace Deposits)				6.80	6.80 6.80-7.60	P*	5/3
		7.70	-3.12		6.80		
Medium dense to dense dark grey silty SAND and subrounded to rounded fine to coarse GRAVEL of siltstone, mudstone and quartz. (Terrace Deposits)					7.70		
				8.00	8.00-8.45 c	"29"	
				9.00	9.00 9.00-9.45 c	"31"	
		10.00	-5.42		10.00		

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

() U100 blows * = No Recovery
P = Piston sample

250mm diameter casing inserted GL - 13.00m
200mm diameter casing inserted GL - 25.30m

Water observations

4/3 Water struck at 6.80m, rose to 1.00m in 20 mins. casing to 6.80m
4/3 (p.m) Water level at 0.85m, casing to 6.80m
5/3 (a.m) Water level at 0.00m, casing to 6.80m. 5/3 (p.m) Water level at 0.40m, casing to 11.60m
6/3 (a.m) Water level at 0.00m, casing to 11.60m 6/3 (p.m) Water level at 1.20m, casing to 13.60m
9/3 (a.m) Water level at 0.00m, casing to 13.60m 9/3 (p.m) Water Level at 0.20m, casing to 20.50m

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 12

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 250/200mm

SJ07NW 32

Sheet 2 of 3
Co-ords 9841E 20175N
Ground Level 4.58 m.A.O.D.
Date 4/3/92 - 11/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Dense to very dense brown silty SAND and subangular to rounded fine to coarse GRAVEL with occasional cobbles, including sandstone, siltstone, mudstone and quartz. (Terrace Deposits)				10.00	10.00-10.45 c	"62"	
11.60-11.90m: possible cobble 12.60-12.80m: possible cobble 13.30-13.50m: possible cobble				11.00	11.00-11.45 c	"44"	5/3
				12.00	12.00-12.45 c	"76"	6/3
below 13.10m: occasionally with a little clay.				13.00	13.00-13.30 c 13.10	58 for 150mm	6/3
				14.00	14.00-14.45 c 14.50	" 52"	9/3
15.20-15.70m: possible cobble				15.00	15.00-15.30 c 15.50	59 for 150mm	
				16.00	16.00-16.45 c 16.50	"63"	
				17.00	17.00-17.45 c 17.50	"47"	
18.40-18.80m: possible cobble				18.00	18.00-18.45 c 18.50	"84"	
				19.00	19.00-19.45 c 19.50	"64"	
		(20.00)	-15.42				

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▥	Piezometer

Remarks (Observations of Ground Water etc.)

Water observations (cont'd)

10/3 (a.m) Water level at 0.00m, casing to 20.50m. 10/3 (p.m) Water level at 1.60m, casing to 25.20m
11/3 (a.m) Water level at 0.00m, casing to 25.20m. 11/3 (p.m) Water level at 0.00m, casing to 25.20m

Permeability Tests
Rising head test undertaken at 6.80m $K = 1.68 \times 10^{-4}$ m/s

Chiselling
10.40-10.80m : 1½ hrs
11.50-11.60m : ½ hr
11.60-11.90m : ½ hr
12.60-12.80m : 1 hr
13.30-13.50m : 1½ hr
15.20-15.70m 1 hr
18.40-18.80m 1 hr
20.30-20.50m ½ hr
21.20-21.60m : 1 hr
24.20-20.50m : 1½ hrs
25.00-25.50m : 1½ hrs
25.50-27.50m : 4½ hrs

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 12

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 250/200mm

SJ 07 NW 32

Sheet 3 of 3
Co-ords 9841E 20175N
Ground Level 4.88 m.A.O.D.
Date 4/3/92 - 11/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Dense to very dense brown silty SAND and subangular to rounded fine to coarse GRAVEL with occasional cobbles, including sandstone, siltstone, mudstone and quartz. (Terrace Deposits)				20.00	20.00-20.45 C 20.50	"72"	9/3
20.30-20.50m: possible cobble				21.00	21.00-21.18 C 21.50	30 for 30mm	10/3
21.20-21.60m: possible cobble				22.00	22.00-22.45 C 22.50	"89"	
				23.00	23.00-23.30 C 23.50	63 for 150mm	
24.20-24.50m: possible cobble				24.00	24.00-24.30 C 24.50	75 for 150mm	
25.00-25.20m: possible cobble				25.00	25.00-25.22 C 25.20	50 for 50mm	
		25.20	-20.62	25.20	25.22-25.34 C 25.50	88 for 115mm seating	10/3
Reddish brown fine to medium grained moderately to highly weathered silty SANDSTONE, very weak to weak. (Lower Mottled Sandstone)				25.20	26.20-26.30 C	88 for 105mm of seating	11/3
Borehole complete at 27.50m		27.50	-22.92	25.20	27.20-27.22 C	50for 20mm of seating	11/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

Double piezometer installed at (1) 8.50m and (2) 20.00m (see details)

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW35

Easting: 301910
Northing: 378120
Date: 1992
Length: 38.00m

Norwest Holst Soil Engineering Ltd.

Borehole No. 15

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 250/200mm

0191,7812
SJ 07 NW 35

Sheet 1 of 5
Co-ords 9706E 20266N
Ground Level 4.16 m.A.O.D.
Date 13/3/92 - 23/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL, soft brown silty clay with occasional cobbles and rootlets.				0.50	0.00 0.50-0.95 c 0.90	"59"	
		0.90	3.26	1.00	1.00-1.45 c	"41"	
Medium dense and dense brown slightly clayey sandy fine to coarse subrounded to rounded GRAVEL of sandstone, mudstone and siltstone and occasional igneous lithologies, occasionally very sandy. ...0.50m: much soft brown silty clay with rootlets, and igneous cobbles of basalt and dolerite. ...3.00m, occasional cobbles. (RIVER TERRACE GRAVELS)				2.00	2.00-2.45 c 2.20	"27"	
				3.00	3.00-3.45 c	"19"	
		3.80	0.36		3.80		
Soft brown fibrous and amorphous clayey PEAT.		4.00	0.16		3.80 4.00		
Very soft to soft grey silty CLAY with some organic detritus and thin partings of fibrous peat. (ALLUVIUM)					4.30 4.60		13/3 16/3
		5.80	-1.64	5.00	5.20-6.00	p*	
Soft brown fibrous PEAT.					5.80		
		6.80	-2.64	6.00	6.00-6.80	p (0.20m rec)	
Soft light grey very silty, occasionally slightly sandy CLAY, with occasional organic traces. (ALLUVIUM)					6.80 7.00-7.80		
				7.00		p*	
Medium dense to dense grey fine to coarse subrounded to rounded GRAVEL of predominantly siltstone and limestone and occasional quartz and sandstone and cobbles. ...10.80m becoming brown. (RIVER TERRACE DEPOSITS)		8.80	-4.64	8.00	8.00-8.50 8.50 8.80	U(46)	
				9.00	9.00-9.45 c 9.50	"29"	16/3 17/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) U(-) = U100 blows * = No recovery
P = Piston sample
250mm diameter casing inserted G.L. - 13.80m.
200mm diameter casing inserted G.L. - 25.50m.
Falling head test carried out at: 6.80m
$K = 7.17 \times 10^{-6}$ m/s

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 15

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 250mm/200mm

SJ 07 NW 35

Sheet 2 of 5
Co-ords 9706E 20266N
Ground Level 4.16 m.A.O.D.
Date 13/3/92 - 23/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Medium dense to dense grey fine to coarse subrounded to rounded GRAVEL of predominantly siltstone and limestone and occasional quartz and sandstone and cobbles. (River Terrace Deposits)				10.00	10.00–10.45 c 10.50 10.80	"54"	12/3
				11.00	11.00–11.45 c	"27"	
		11.70	-7.54		11.70		
Firm to stiff brown silty sandy CLAY with occasional fine subangular and subrounded gravel of sandstone, siltstone and mudstone, and occasional assorted igneous lithologies. (GLACIAL TILL)				11.80	11.80–12.30 12.30	(110)	
				12.80	12.80–13.30 13.30	(127)	
		13.80	-9.64		13.80		17/3
Dense brown slightly clayey SAND and fine occasionally medium angular to rounded GRAVEL of sandstone, mudstone limestone, siltstone and assorted igneous lithologies. (GLACIAL SAND AND GRAVELS)		14.00	-9.84	13.80	13.80–14.10 c 14.00	"52 for 150mm"	18/3
				14.50	14.50–14.60	(120) N.R	
				15.00	15.00	(100) N.P	
		15.50	-11.34	15.50	15.50	(100) N.P	
Very stiff brown sandy silty CLAY with some fine to coarse subangular to rounded gravel of mudstone, siltstone and limestone. (GLACIAL TILL)				16.00	16.00 16.00–16.45 c	"46"	
Dense and very dense brown very clayey very sandy fine to coarse angular to rounded GRAVEL of mudstone limestone, siltstone, sandstone and assorted igneous lithologies and with occasional cobbles. (GLACIAL GRAVELS)				17.00	17.00–17.30 c	"62for 150mm"	
				18.00	18.00–18.45 c	"63"	
				19.00	19.00–19.30 c	"66for 150mm"	
							18/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

NP : No Penetration (-) U100 blows
NR : No Recovery

Groundwater encountered at: 13/3/92: Struck at 2.20m, rising to 1.60m after 20 mins, cased to 2.20m.
p.m standing water level : 3.50m, casing 4.60m.
16/3/92: am standing water level; 3.30m, casing 4.60m.
struck 8.80m, rising to G.L after 20 mins, casing 9.00m.
17/3/92: Overnight standing water level: G.L., casing 9.00m
pm standing water level: 1.30m, casing 13.80m
18/3/92: Overnight standing water level: + 0.70m, casing 13.80m
pm standing water level : G.L., casing 20.50m.

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 15

BOREHOLE LOG

Contract No. F9440
Location. A525 Rhuddlan Bypass - Stage II
Client. Clwyd County Council
Method of Boring. Cable Percussion
Diameter of Borehole. 250mm/200mm

SJ 07 NW 35

Sheet 3 of 5
Co-ords 9706E 20266n
Ground Level 4.16 m.A.O.D.
Date 13/3/92 - 23/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Dense and very dense brown very clayey very sandy fine to coarse angular to rounded GRAVEL of mudstone limestone, siltstone, sandstone and assorted igneous lithologies and with occasional cobbles. (GLACIAL GRAVELS)				20.00	20.00-20.45 C		18/3
							19/3
				21.00	21.00-21.30 C	"53 for 150mm"	
				22.00	22.00-22.45 C	"72"	
				23.00	23.00-23.15 C	"77 for * 150mm"	
		24.00	-19.84				
Dense brownish grey fine to coarse silty SAND with occasional to some fine to medium subangular sandstone fragments. (Gradational)				24.00	24.00-24.45 C 24.10	"41"	
				25.00	25.00-25.45 C	"50"	
		25.40	-21.24		25.40		
Reddish brown fine to coarse moderately to highly weathered silty SANDSTONE, weak.				25.50	25.50-25.60 S	"82 for * 105mm"	
				25.50	26.50-26.55 S	"50 for 50mm*"	
				25.50	27.50-27.52 S	"50 for 20mm*"	19/3 23/3
		28.02	-23.86	25.50	28.00-28.02 C	"50 for 25mm*"	23/3
Cable Percussion Complete at 28.02m Rotary follow on							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) * Seating blows only

19/3/92: Overnight standing water level - +0.7m, casing 20.50m.
: pm standing water level - G.L, casing 25.80m
23/3/92: Overnight standing water level - G.L, casing 25.80m
pm standing water level - +0.5m, casing 25.80m.

Chiselling: 0.60-1.00m, 1½ hrs; 1.50-1.80m, 1 hr; 10.30-10.70m, 1½hrs; 13.40-13.80m, 2 hrs; 14.50-15.70m, 2 hrs; 17.30-17.70m, 1 hr; 19.10-19.60m, 1 hr; 23.00-23.40m, 1 hr; 25.50-27.50m, 4½ hrs; 27.50-28.00m, 1½ hrs

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 15

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 146mm

SJ 07 NW
35

Sheet 4 of 5
Co-ords 9706E 20266N
Ground Level 4.16 m.A.O.D.
Date 27/3/92 - 29/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Previously shell and augered G.L. to 28.00m.							
Reddish brown fine to coarse grained moderately weathered SANDSTONE weak. (recovered as gravel) (Lower Mottled Sandstone)		28.00	-23.84	F/F per metre	TCR % SCR % RQD %		
Reddish brown fine to coarse grained thinly laminated to very thinly bedded slightly weathered SANDSTONE weak with occasional black micaceous laminae, cross bedding evident. (Lower Mottled Sandstone)		28.67	-24.51	>20	28.00		27/3
				>20	94 38	7	

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▥	Piezometer

Remarks (Observations of Ground Water etc.)

Rig: Edeco strata 20
Barrel: SWF double tube core barrel with core liner
Bit: Diamond
Flush: Foam
Groundwater: Overnight standing level at G.L.
2 Piezometers installed 1) tip at 10.00m, sand filter 9.00-11.00m
2) tip at 24.00m sand filter 23.00-25.00m
Packer permeability testing carried out in test sections 29.50-30.50m, 31.00 to 32.00m and 34.00 to 35.00m.

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 15

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 146mm

SJ 07 NW 35

Sheet 5 of 5
Co-ords 9706E 20266N
Ground Level 4.16 m.A.O.D.
Date 27/3/92 - 29/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Joints parallel to bedding at 10-20°, extremely closely to closely spaced, planar to undulose, rough. 45° fractures, closely to medium spaced, irregular to planar, rough. 30.41-30.68m recovered as gravel.		30.68	-26.58	> 20			
					31.00		
Reddish brown fine to coarse grained slightly weathered SANDSTONE weak to moderately weak with occasional cross bedding. Joints parallel to bedding at 20°, closely spaced, undulose to irregular rough. 45° fractures, closely to medium spaced, planar to irregular, rough. At 31.46m and 31.48m 2 No. sub-parallel 10° fractures, irregular, rough. At 32.41m 10° fracture, irregular, rough. At 33.18m 10° fracture, irregular, rough. (Lower Mottled Sandstone) 34.81-35.00m thickly laminated to thinly bedded. 35.58-35.89m Set of 3 No. subparallel 70° fractures, planar to irregular rough.				> 20			
				> 20	95 70	20	
				15			
					34.00		
				20			
				20	97 53	24	
				16			
					37.00		
...Below 37.00m, occasionally moderately strong ...Below 37.15m with some black micaceous laminae. 37.28-37.37m 60° fracture, curviplanar rough, black staining on surface.				15	95 64	29	
ROTARY BOREHOLE COMPLETE AT 38.00m.		38.00	-33.16		38.00		27/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

Packer Permeability Tests carried out at:
1) 29.50-30.50m, K = 2.09 x 10-5 m/s L = 209 UNITS
2) 31.00-32.00m, K = 1.81 x 10-5 m/s L = 181 UNITS
3) 33.00-34.00m, K = 2.21 x 10-5 m/s L = 221 UNITS

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW36

Easting: 301930
Northing: 378170
Date: 1992
Length: 37.30m

Norwest Holst Soil Engineering Ltd.

Borehole No. 16

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200mm to 12.00m, 150mm to 27.35m

0193 7817
SJ 07 NW
36

Sheet 1 of 5
Co-ords 9670E 20295N
Ground Level 3.90 m.A.O.D.
Date 19/3/92 - 27/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL.		0.15	3.75		0.15		19/3
Very soft becoming soft grey mottled dark grey very silty sandy CLAY with occasional pockets of organic detritus. ...1.25m, occasional brown fibrous roots. (Alluvium)					0.15-0.55 0.55-1.05 1.05 1.25 1.45-1.90 1.90 2.30 2.40-2.80	P (9) P	
		2.80	1.10		2.80		
Loose grey brown fine and medium SAND and fine to coarse subrounded GRAVEL of quartz, sandstone and mudstone. (ALLUVIAL SANDS & GRAVELS)					2.90-3.35 c 3.60 3.90-4.35 c 4.65 4.85-5.30 c	"9" "10" "8"	19/3 20/3
		5.10	-1.20		5.20-5.40		
Soft, occasionally very soft, grey and dark grey silty CLAY with much fibrous organic detritus. ...5.20m with occasional fine to coarse subrounded gravel of quartz, sandstone and mudstone. ...7.20m, with occasional fine gravel sized pockets of brown amorphous organic detritus. ...8.00m, becoming firm. (ALLUVIUM)					5.20 5.40-5.85 5.85 6.10 6.20-7.00 7.20 7.30-7.75 7.75 8.00-8.45	(7) P (12) (26)	
Dense grey fine to coarse SAND and fine to coarse rounded GRAVEL of sandstone, mudstone and quartz and occasional igneous lithologies, occasional cobbles and occasional boulders. (ALLUVIAL SANDS & GRAVELS)		9.00	-5.10		8.45 8.65 8.90 9.00 9.10-9.55 c 9.75 9.90	"34"	20/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) ( ) U100 Blows
P Piston Sample

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 16

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200mm to 12.00m, 150mm to 27.35m

SJ07NW 36

Sheet 2 of 5
Co-ords 9670E 20295N
Ground Level 3.90 m.A.O.D.
Date 19/3/92 - 27/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Dense grey fine to coarse SAND and fine to coarse rounded GRAVEL of sandstone, mudstone and quartz and occasional igneous lithologies, occasional cobbles and occasional boulders. (ALLUVIAL SANDS & GRAVELS)		10.20	-6.30		10.20 10.20 10.20-10.45 10.45-10.90 10.90 11.15 11.40-11.80 11.80 12.10 12.40-12.85 12.85 13.10 13.40-13.85 13.85 14.15 14.40-14.80 14.85 15.15 15.45-15.90 15.90 16.15 16.40-16.85 16.85 17.10 17.45-17.90 17.90 18.00-18.45 c	(100) (103) (100) (80) (70) (73) (54) (49) "31"	25/3
Stiff brown silty sandy CLAY with some to much fine to medium rounded gravel of quartz, sandstone, siltstone, mudstone and various igneous lithologies. ...below 14.40m: becoming soft to firm, occasionally firm. (GLACIAL TILL)							
Very dense grey fine to coarse SAND and fine to medium rounded GRAVEL of quartz, sandstone, mudstone, siltstone and various igneous lithologies and with a little clay, occasionally much clay. (GLACIAL SANDS & GRAVELS)							
Stiff brown silty sandy CLAY with some fine to medium subrounded gravel of quartz, siltstone and occasional sandstone and with occasional thin silt partings. (GLACIAL TILL)		18.70 19.85	-14.80 -15.95		18.70 19.00-19.20 19.21-19.65 c 19.85	(100) N.R "55"	25/3 26/3 26/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk		Piezometer

Remarks (Observations of Ground Water etc.) NR : No Recovery ( ) U100 blows
Rising Head Test carried out at 2.80m. K = 3.24 x 10^{-4} m/s
Groundwater encountered at: 19/3/92 2.80m, rising to 1.60m after 20 mins, casing at 2.40m.
20/3/92 Overnight standing water level 0.40m struck 9.00m, rising to 0.50m above G.L after 20 mins.
25/3/92 Overnight standing water level G.L.
26/3/92 Overnight standing water level 11.50m, struck 24.60m, rising to 0.4m after 20mins

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 16

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200mm to 12.00m, 150mm to 27.35m

SJ 07 NW
36

Sheet 3 of 5
Co-ords 9670E 20295N
Ground Level 3.90 m.A.O.D.
Date 19/3/92 - 27/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Stiff brown silty sandy CLAY with some fine to medium subrounded gravel of quartz, siltstone and occasional sandstone and with occasional thin silt partings. (GLACIAL TILL)					20.15-20.45 c 20.70 O 21.00-21.15 c 21.00-21.50 21.75 O	"86for 150mm "74for 150mm*"	26/3
		21.75	-17.85				
Very dense grey fine to coarse SAND and fine and medium subrounded GRAVEL of sandstone, mudstone, siltstone and assorted igneous lithologies and with some clay. (GLACIAL SANDS & GRAVELS)					22.00-22.30 22.00-22.50 c 22.70 O	"68for 150mm" "68for 150mm"	
		22.75	-18.85				
Very stiff brown silty CLAY with occasional fine gravel of quartz and occasional white shell fragments. (ALLUVIAL CLAY)					23.00-23.45 c 23.70 O	"77"	
		23.70	-19.80				
		24.00	-20.10				
Dense to very dense reddish brown silty clayey fine SAND with some fine to medium subrounded gravel and occasional rounded cobbles, and with occasional white shell fragments. (Reworked/Completely weathered lower mottled sandstone)					24.00-24.30 24.60 △ 24.60 24.65-24.70 s 24.60-25.00 25.50 O	"68for 150mm" "50for NP*"	26/3 27/3
Reddish brown fine to coarse grained moderately weathered SANDSTONE, weak. (LOWER MOTTLED SANDSTONE)					25.80-26.10 c 26.50 O	"63for 150mm"	
Cable Percussion complete at 27.35m Rotary follow on.					26.80-26.95 c 26.80-27.20 27.20-27.35 c	"73for 150mm*" "80for 150mm*"	27/3
		27.35	-23.45				

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
O	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) * Seating blows only NR-No Recovery
N.P No Penetration

Groundwater encountered at 27.3.92; overnight standing water level 0.40m above G.L.

Chiselling:
9.55-10.00 1 hr
20.45-22.00 3½ hrs
22.30-22.70 1 hr
24.65-25.00 1 hr
25.00-25.80 1¾ hrs
26.80-27.20 1 hr

Insitu Borehole Vane testing carried out at;

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 16

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council SJ07 NW
Method of Boring Rotary
Diameter of Borehole 146mm 36

Sheet 4 of 5
Co-ords 9670E 20295N
Ground Level 3.90 m.A.O.D.
Date 31/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Reddish brown fine to coarse grained very thinly to thinly bedded slightly weathered SANDSTONE weak with some black micaceous laminae. Cross bedding evident. Joints parallel to bedding at 2-30° very closely to closely spaced, planar to irregular, rough. Incipient fractures, very closely to medium spaced, irregular to curvi-planar, random. 30° fractures, very closely to medium spaced irregular, rough. ...Below 28.91m 45° fractures, closely to medium spaced, planar to irregular, rough.		27.30	23.40	F/F per metre >20 >20 >20	TCR % SCR % 27.30 99 55 29.80	RQD % 8	

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)
Rig: Edeco Strata 20
Barrel: SWF double tube core barrel with core liner
Bit: Diamond
Flush: Foam
Groundwater: Overnight standing level at G.L.
2 Piezometers installed 1) tip at 4.00m, sand filter 3.50-4.50m.
2) tip at 15.00m, sand filter 14.00-16.00m

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 16

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 146mm

SJ 07 NW
36

Sheet 5 of 5
Co-ords 9670E 20295n
Ground Level 3.90 m.A.O.D.
Date 31/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
29.40-29.80m non-intact.		30.16	-26.26				
Reddish brown fine to coarse grained thinly laminated to very thinly bedded slightly weathered SANDSTONE weak with some micaceous laminae, 10° fractures, extremely closely to closely spaced, planar, rough. 30.16-30.73m 3 No. subparallel 60° fractures, planar to irregular, rough 30.72-30.84m Subvertical fracture, planar to stepped, rough.		30.84	-26.94	>20	91 55	14	
Reddish brown fine to coarse grained very thinly to thinly bedded slightly weathered SANDSTONE weak to moderately weak. Joints parallel to bedding at 20-30° very closely to closely spaced, planar, rough subhorizontal fractures, medium spaced, irregular to undulose, rough. 32.13-32.17m 25° fracture planar, rough. 32.84-32.91m 2 No. subparallel 30° fractures, curviplanar, rough. 34.13-34.20m 70° fracture, curviplanar to irregular, rough. 34.58-34.82m 2 No. 45° fractures, irregular to curviplanar, rough. 34.98-35.07m 70° fracture, curviplanar to undulose, rough. 35.46-35.70m subvertical fracture, irregular, rough. ...Below 35.79m 45° fractures, closely to medium spaced, irregular to undulose, rough. ...Below 36.38m 80° fracture, closely to medium spaced, irregular, rough.				19	32.50		
				20			
				>20	94 76	30	
				18	35.20		
				20	93 72	17	
				>20			
		37.30	-33.40		37.30		
ROTARY BOREHOLE COMPLETE AT 37.30m.							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk		Piezometer

Remarks (Observations of Ground Water etc.)

Packer Permeability tests carried out at:

1) 28.85-29.85m, K = 4.10 x 10-5 m/s, L = 410 UNITS
2) 30.35-31.35m, K = 5.27 x 10-5 m/s, L = 527 UNITS
3) 32.35-33.35m, K = 2.93 x 10-5 m/s, L = 293 UNITS

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW37

Easting: 301950
Northing: 378200
Date: 1992
Length: 27.75m

Norwest Holst Soil Engineering Ltd.

Borehole No. 17

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Cable Percussion 0195, 7820 SJ07NW 37
Diameter of Borehole 200mm/150mm
Sheet 1 of 3
Co-ords 9647E 20318N
Ground Level 4.34 m.A.O.D.
Date 12/3/92 - 18/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL		0.15	4.16		0.15		
Greyish brown very sandy clayey subrounded to rounded fine to coarse GRAVEL, including sandstone, siltstone, mudstone. Rootlets.		0.60	3.74		0.45-0.90	"1"	
					C		
					0.60		
					1.10-1.55	U(16)	
					1.55		
Soft to firm grey mottled brown silty CLAY. Occasional rootlets. (Alluvium)					1.65-2.10	U(24)	
1.55-2.10m: brown, firm in parts.		2.10	2.24		2.10		
					2.30-2.75	U(21)	
Firm grey fissured silty CLAY. (Alluvium)		2.75	3.59		2.75		
		2.85	1.49		2.85		
Brown fibrous clayey PEAT.		3.45	0.89		3.00-3.45	U(13)	
					3.45		
Very soft grey slightly peaty silty CLAY. (Alluvium)					3.60-4.05	U(13)	
					4.05		
Brown fibrous clayey PEAT. (Alluvium)		4.40	-0.06		4.30		
4.05-4.40m: soft brown very peaty silty clay.					4.55-5.00	U(5)	
					5.00		
Very soft grey silty CLAY, with occasional sand laminae. (Alluvium)					5.20-6.00	P	
					6.00		12/3
					6.20		13/3
					6.20-7.00	P	
					7.00		
					7.15-7.90	P	
Brown fibrous PEAT		7.90	-3.56		8.00		
		8.00	3.66		8.05-8.50	U(40)	
Soft light grey very silty CLAY. (Alluvium)					8.50		
					8.75		
					9.00-9.45	U(38)	
Soft grey mottled silty CLAY. (Alluvium)		9.45	-5.11		9.45		
9.45-9.75m: very occasional organic matter.					9.75		
9.75-10.00m: occasional rounded fine to medium gravel.		10.00	-5.66		10.00		

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

() U100 blows * No recovery
P = Piston sample

200mm diameter casing inserted GL - 9.00m
150mm diameter casing inserted GL - 27.75m

Water observations:
13/3 Water struck at 10.00m, rose quickly to 0.60m after 20 mins. casing to 9.00m
16/3 (a.m) Water level at 0.60m, casing to 9.00m. 16/3 (p.m) Water level at 20.20m casing to 22.25m
17/3 (a.m) Water level at 1.60m, casing to 22.25m. 17/3 (throughout day) water level at 3.00m

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 17

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200mm/150mm

SJ 07 NW 37

Sheet 2 of 3
Co-ords 9647E 20318N
Ground Level 4·34 m.A.O.D.
Date 12/3/92 - 18/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Medium dense greyish brown sandy subrounded to rounded fine to coarse GRAVEL, including sandstone, siltstone, limestone, quartz. (Terrace Deposits)		10.70	-6.36		10.05-10.50 c 10.00 10.70	"17"	13/3 16/3
Firm to stiff brown silty CLAY with occasional gravel and cobbles. (Glacial Till) 10.70-10.80m: very sandy		11.20	-6.86		10.80-11.25 c 11.20 11.35-11.80 11.80	"17" U(79)	
Stiff, in parts firm to stiff, brown silty CLAY with occasional partings of light brown silt and fine sand. (Glacial Till) below 13.00m: firm and with very occasional rounded gravel.					12.05 12.40-12.85 12.85 13.00 13.35-13.80 13.80 14.05 14.30-14.75 14.75 15.00 15.30-15.75 15.75	U(80) U(48) U(41) U(38)	
16.00-16.80m: soft to firm indistinctly laminated.		18.00	-13.66		16.00 16.35-16.80 16.80 17.10 17.30-17.75 17.75	U(38) U(38)	
Dense brown clayey very sandy subangular to rounded fine to coarse GRAVEL, including sandstone, siltstone, limestone, quartz. (Glacial Sands & Gravels)		(20.00)	-15.66		18.00 18.25-18.60 18.80-19.25 c 19.50 19.70-20.15	U(80)* "34" U(78)	

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

Chiselling

21.40-22.00m 1¾ hrs
22.50-24.00m 3¼ hr
26.00-27.75m 4 hrs

Piezometer installed at 10.50m (see details)

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 17

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200mm/150mm

SJ 07 NW 37

Sheet 3 of 3
Co-ords 9647E 20318N
Ground Level 4:34 m.A.O.D.
Date 12/3/92 - 18/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Dense brown clayey very sandy subangular to rounded fine to coarse GRAVEL, including sandstone, siltstone, limestone, quartz. (Glacial Sands & Gravels)					20.15 12.00-12.50 17.00-17.50 20.40 20.65-21.00	U(100)*	
below 21.40m: very dense					21.10-21.40 c	68 for 140mm	
					21.65 22.00-22.15 c	85 for seating	16/3
					22.00-22.50 10.50 22.75	only	17/3
				22.50	23.00-23.15 c 23.00-23.50	86 for seating only	
					23.75		
				23.50	24.00-24.20 c 24.00-24.59 22.00-24.00 24.70	50 for 50mm	
					25.05-23.35 c 25.05-25.50	56 for 150mm	
		25.70	21.36				
Reddish brown fine to medium grained highly to completely weathered silty SANDSTONE, very weak. (Lower Mottled Sandstone)					25.70 25.75-25.85 25.75-26.00 26.25 26.50	75 for seating only	
26.75-27.75m: predominantly highly weathered, very weak.					26.75-26.80 c 26.75-27.50 27.25	50 for 50mm of seating	
Borehole complete at 27.75m		27.75	23.41		27.50-27.55 27.50 27.00-27.50	50 for No pen	17/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW41

Easting: 302000
Northing: 378350
Date: 1992
Length: 39.00m

Norwest Holst Soil Engineering Ltd.

Borehole No. 21

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass -Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200 / 150m

0200, 7835
SJ 07 NW 41

Sheet 1 of 5
Co-ords 9520E 2042N
Ground Level 5.11 m.A.O.D.
Date 4/3/92 - 6/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
TOPSOIL.		0.25	4.86		0.25		
Stiff brown mottled grey slightly sandy silty CLAY with occasional gravel and rootlets. (Glacial Till). at 0.25m...firm and sandy.		1.40	3.71	0.00	0.45-0.90	U(68)	
					0.90		
					1.15		
					1.40		
Stiff to very stiff brown slightly sandy silty CLAY with occasional to some sub-angular to rounded fine to coarse gravel. (Glacial Till) below 4.20m...occasional gleyed fissures and rootlets. 4.95-5.60m...in parts laminated and with occasional cobbles.				0.00	1.45-1.90	U(83)	
					1.90		
				1.50	2.45-2.90	U(110)	
					2.90		
					3.20		
				3.00	3.50-3.95	U(90)	
					3.95		
					4.20		
				3.00	4.55-5.00	U(83)	
					5.00		
				4.60	5.05-5.50	U(91)	
		5.60	-0.49		5.55		
Loose brown clayey SILT.		5.80	-0.69		5.60		
					5.60		
					5.85		
Firm to stiff brown silty CLAY with occasional sub-angular to rounded fine to coarse gravel and with occasional lenses and partings of sand. (Glacial Till) 5.80-6.50m...firm. 7.10-7.55m...firm, slightly sandy and with some brown fine to coarse sand. below 8.30m...with occasional cobbles.				6.00	6.00-6.45	U(48)	
				6.60	6.60-7.05	U(53)	
				6.90	7.10-7.55	"20"	
					c		
				7.25	7.65-8.20	U(36)	
					8.20		4/3 -
					8.45		5/3
				8.40	8.65-9.20	U(40)	
					9.20		
					9.45		
		10.00	-4.89	9.00	9.70-10.15	U(43)	

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) U(-) = U100 blows

200mm diameter casing inserted G.L.-12.50m

Ground water

4/3 Water strike at 5.60m, casing to 4.60m, sealed off at 6.00m.
5/3 Water strike at 10.00m, rose to 8.50m in 20mins, casing to 9.00m, sealed off at 12.50m.
6/3 (a.m) water level at 1.50m, casing to 12.50m; water level at 3.00m whilst boring.

Chiselling

28.00-29.00m: 2½ hrs

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 21

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200 / 150m
SJ 07 NW 41
Sheet 2 of 5
Co-ords 9520E 20421N
Ground Level 5.11 m.A.O.D.
Date 4/3/92 - 6/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Firm to stiff brown silty CLAY with occasional sub-angular to rounded fine to coarse gravel and with occasional lenses and partings of sand. (Glacial Till).				10.00	10.15 10.35 10.50-10.95	U(33)	
					10.90		
				11.20	11.20 11.45-11.90	U(41)	
					11.90		
...12.60m: becoming very sandy with much gravel.				12.50	12.20 12.60-13.05	U(41)	
					13.05		
				12.50	13.30 13.55-14.00	U(48)	
14.00-15.25m...firm.					14.00 14.25		
				12.50	14.50-14.95	U(48)	
		15.25	-10.14		14.95 15.25		
Firm to stiff brown silty CLAY with very occasional rounded gravel. (Glacial Till) 15.25-16.00m...firm.				12.50	15.55-16.00	U(39)	
					16.00 16.25		
				12.50	16.50-16.95	U(38)	
					16.95 17.20		
				12.50	17.45-17.90	U(35)	
below 17.90m...becoming stiff.					17.90		
				12.50	18.50-18.95	U(40)	
					18.95 19.20		
		20.00	-14.89	12.50	19.55-20.00	U(43)	

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▦	Piezometer

Remarks (Observations of Ground Water etc.)

Falling head test undertaken at 5.50m. $k = 9.11 \times 10^{-7}$ m/s
Rising head test undertaken at 5.80m. $k = 1.01 \times 10^{-5}$ m/s

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 21

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass. - Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 200/150m

SJ 07 NW 41

Sheet 3 of 5
Co-ords 9520E 20421N
Ground Level 5.11 m.A.O.D.
Date 4/3/92 - 6/3/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Firm to stiff brown silty CLAY with very occasional rounded gravel. (Glacial Till)		21.25	-16.14	12.50	20.00 20.25 20.50-20.95 20.95 21.25	U(44)	
Soft grey mottled brown laminated silty CLAY. (Laminated clay)		22.40	-17.29	12.50	21.55-22.00 22.00 10.00 22.25 22.40	U(41)	5/3
Medium dense brown silty SAND and sub-angular to rounded fine to coarse GRAVEL, of sandstone, siltstone of quartz. (Glacial Sands & Gravels)		25.45	-20.34	12.50 12.50	22.40-22.60 22.60-23.05 c 23.30 23.65-24.10 c 24.35	"15" "17"	6/3
Dense reddish brown and brown silty SAND and sub-angular to rounded fine to coarse GRAVEL of sandstone, siltstone and quartz. (Glacial Sands & Gravels)		26.50	-21.39	12.50	25.45 25.55-26.00 c 26.25	"39"	
Dense reddish brown silty fine to coarse SAND with occasional gravel of sandstone, siltstone and quartz. (Glacial Sands & Gravels)		27.20	-22.09	12.50	26.50-26.95 c 27.20	"31"	
Reddish brown fine to medium grained moderately to highly weathered silty SANDSTONE, very weak to weak. (Lower Mottled Sandstone) 28.50-29.05m...weak to moderately weak. Cable Percussion Complete at 29.05m.		29.05	-23.94	12.50 12.50 12.50	27.50-27.70 c 28.05 28.45-28.75 c 28.50-29.00 29.05 c 22.40	50for 55mm 82 for 150mm 50 for No pen	6/3

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.)

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 21

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 146mm

SJ07NW 41

Sheet 4 of 5
Co-ords 9520E 20421N
Ground Level 5.11 m.A.O.D.
Date 24/2/92 - 26/2/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Previously shell and augered G.L. to 29.00m.							
Reddish brown fine to coarse grained very thinly to thinly bedded slightly weathered SANDSTONE weak to moderately weak. Joints parallel to bedding at 20-30°, very closely to closely spaced, planar to irregular, rough. Subhorizontal fractures, medium spaced, irregular to undulose, rough.		29.00	-23.89	F/F per metre	TCR % SCR % 29.00	RQD %	24/2
				17			

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▦	Piezometer

Remarks (Observations of Ground Water etc.)

Rig : Edeco H40
Barrel : SWF Double tube core barrel with core liner
Bit : Diamond
Flush : Foam
Groundwater: overnight standing level at G.L.
2 Piezometers installed 1) tip at 14.00m, sand filter 13.00-15.00m
2) tip at 28.00m, sand filter 27.00-29.00m

Water levels are subject to seasonal or tidal variations and should not be taken as constant

Norwest Holst Soil Engineering Ltd.

Borehole No. 21

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass - Stage II
Client Clwyd County Council
Method of Boring Rotary
Diameter of Borehole 146mm

SJ 07 NW 41

Sheet 5 of 5
Co-ords 9520E 20421N
Ground Level 5.11 m.A.O.D.
Date 24/2/92 - 26/2/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
30.11-30.16m 50° fracture, irregular to curviplanar, rough. 30.74-30.78m 40° fracture, irregular rough. 31.00-32.16m Joints parallel to bedding become extremely closely and closely spaced.				13 9	98 94	39	
					32.00		
...Below 33.00m becomes less coarse grained, thinly to medium bedded. 33.20-33.35m 70° fracture, curvi-planar to irregular, rough. ...At 33.83m 2mm resealed 30° fracture cemented silty clay infill.				10 8 5	96 90	67	
					35.00		
...Below 35.66m becomes very thinly to thinly bedded. Joints parallel to bedding become very closely to closely spaced. 35.66-35.71m 40° fracture, irregular rough. 36.32-36.40m 50° fracture, curvi-planar, rough.				10 14 8	97 83 96 95	62 60	24/2 25/2
					36.00		
38.21-38.25m 30° fracture, irregular to undulose, rough. 38.69-38.74m 50° fracture, curvi-planar to planar, rough.				9			
		39.00	-33.89		39.00		25/2
ROTARY BOREHOLE COMPLETE AT 39.00m.							

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▦	Piezometer

Remarks (Observations of Ground Water etc.)

Packer Permeability Tests Carried out at:
1) 30.55-31.55m, K = 2.55 x 10^{-5} m/s, L = 255 UNITS
2) 32.05-33.05m, K = 2.39 x 10^{-5} m/s, L = 239 UNITS
3) 34.05-35.05m, K = 1.34 x 10^{-5} m/s, L = 134 UNITS

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW56

Easting: 302140
Northing: 378730
Date: 1992
Length: 5.25m

Norwest Holst Soil Engineering Ltd.

Borehole No. 39

BOREHOLE LOG

Contract No. F9440
Location A525 Rhuddlan Bypass, Stage II
Client Clwyd County Council
Method of Boring Cable Percussion
Diameter of Borehole 150mm

0214,7873
SJ 07 NW 56

Sheet 1 of 1
Co-ords 9210E 20672N
Ground Level 10.70 m.A.O.D.
Date 19/2/92

Description of Strata	Legend	Depth Below G.L.(m)	O.D. Level (m)	Casing Depth at Sampling	Sampling and Coring	"N"/ R.Q.D.%	Daily Progress
Grass over TOPSOIL		0.30	10.40		0.30		
Firm to stiff brown mottled sandy silty CLAY with some rounded fine to coarse gravel. (Glacial Till)		0.60	10.10		0.50-0.95 C 0.95	"8"	
Soft reddish brown mottled greyish brown sandy silty CLAY with some subangular to rounded fine to coarse gravel. Occasional reddish brown silty fine to medium sand. (Glacial Till)		1.50	9.20		1.15-1.60 1.60 1.90 2.15-2.50	U(24) * U(140)	
Firm to stiff brown slightly sandy silty CLAY with some subangular to rounded fine to coarse gravel. (Glacial Till) at 2.15m: cobble					2.65-3.10 3.35 3.70-4.15 4.15 4.40 4.65-5.10	U(31) U(33) U(56)	
Borehole complete at 5.25m		5.25	5.45		5.10		19/2

Type of Sample

Is	S.P.T.	■	Undisturbed
Ic	C.P.T.	x	Vane
0	Jar	△	Water
●	Bulk	▮	Piezometer

Remarks (Observations of Ground Water etc.) () U100 blows
* driving boulder (no recovery)

150mm diameter casing inserted GL - 3.00m

Groundwater not encountered

Borehole backfilled with bentonite/cement grout

Water levels are subject to seasonal or tidal variations and should not be taken as constant

BGS BOREHOLE REFERENCE: SJ07NW103

Easting: 301100
Northing: 378400
Date: -
Length: 17.68m

23—1.TIF

RECORD OF WELL

For Institute use only Licence No.

N .....

SJ07/23

95/41

At .....Glan...aber.....

.....

Town or Village .....Rhuddlan.....

County .....Flint.....

EXACT SITE OF WELL

Six-inch National Grid sheet and reference .....SJ 011 784.....SJ07NW.....

For .....S. E. Owens.....

State whether owner, tenant, builder, contractor, consultant, etc.: .....owner.....

Address (if different from above) .....

.....

Level of ground surface above sea level (O.D.) ..... ft (.....m)

*DELETE AS NECESSARY

If well top is not at ground level state how far above:* below: .....ft (.....m)

SHAFT.....ft (.....m); diameter.....ft (.....m);

HEADINGS (please attach details—dimensions and directions)

BORE....58.....ft (.....m); diameter: at top.....2.....in (.....mm);

at bottom.....in (.....mm)

Full details of permanent lining tubes (position, length, inner and outer diameters, plain slotted etc.):

.....

.....

.....

.....

Water struck at depths of .....ft (.....m) below well top

TEST CONDITIONS

Rest level of water.....ft (.....m) above* below well top. Suction at..... ft (..... m)

Yield on.....hours'* days' test pumping at.....galls per ..... (..... l/s) with depression to.....ft (.....m) below well top. Recovery to rest level in ..... mins* hours

Capacity of pump.....g.p.h. (.....l/s)

Date of measurements.....

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type ..... Motive power.....

Capacity.....galls (.....m³) per hour. Suction at ..... ft (..... m) below well top. Amount pumped.....galls (.....m³) per day. Estimated consumption .....galls (.....m³) per week

Well made by ..... Date of sinking.....

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

licence No. 24/66/7/12/G for 1750 gpd, 0.263 mga.

LOG OF STRATA OVERLEAF

Received from Dee & Clwyd RA.

.....

.....

Date ...5.8.68.....

Observation well.....

Recorder .....

ER log .....

Site marked on

1" map .....

6" map—Grid Sheet.....

(use symbol)

Copy to.....

.....

Date.....

INSTITUTE OF GEOLOGICAL SCIENCES
HYDROGEOLOGY UNIT
EXHIBITION ROAD
LONDON SW7 2DE

IGS 2494 10 000 7/79

BGS BOREHOLE REFERENCE: SJ07NW105

Easting: 300800
Northing: 377800
Date: -
Length: 18.29m

26 – 1.TIF

RECORD OF WELL

For Institute use only Licence No.

N .....

SJ 07/26

95/43

At ..Mersa Lodge Farm.....

.....

Town or Village .Rhuddlan.....

County .....Flint.....

EXACT SITE OF WELL

Six-inch National Grid sheet and reference .....SJ 008 778 SJ07NW..

For .....D.A. Hughes.....

State whether owner, tenant, builder, contractor, consultant, etc.: .....owner.....

Address (if different from above) .....

.....

Level of ground surface above sea level (O.D.) ..... ft (.....m)

*DELETE AS NECESSARY

If well top is not at ground level state how far above:* below: .....ft (.....m)

SHAFT....60....ft (.....m); diameter...nk....ft (.....m);

HEADINGS (please attach details—dimensions and directions)

BORE.....ft (.....m); diameter: at top.....in (.....mm);

at bottom.....in (.....mm)

Full details of permanent lining tubes (position, length, inner and outer diameters, plain slotted etc.):

.....

.....

.....

.....

Water struck at depths of .....ft (.....m) below well top

TEST CONDITIONS

Rest level of water.....ft (.....m) above* below well top. Suction at.....ft (.....m)

Yield on.....hours'* days' test pumping at.....galls per ..... (..... l/s) with depression to.....ft (.....m) below well top. Recovery to rest level in ..... mins* hours

Capacity of pump.....g.p.h. (.....l/s)

Date of measurements.....

NORMAL CONDITIONS

DESCRIPTION OF PERMANENT PUMPING EQUIPMENT:

Make and/or type ..... Motive power.....

Capacity.....galls (.....m³) per hour. Suction at ..... ft (.....m) below well top. Amount pumped.....galls (.....m³) per day. Estimated consumption .....galls (.....m³) per week

Well made by .....nk..... Date of sinking.....nk.....

ADDITIONAL NOTES ANALYSIS (please attach copy if available)

License No. 24/66/7/18/G for 200gpd, 0.037 mga.

LOG OF STRATA OVERLEAF

Received from Dee & Clwyd RA

.....

.....

Date ....5-8-68.....

Observation well.....

Recorder .....

ER log .....

Site marked on

1" map .....

6" map—Grid Sheet.....

(use symbol)

Copy to.....

.....

Date.....

INSTITUTE OF GEOLOGICAL SCIENCES
HYDROGEOLOGY UNIT
EXHIBITION ROAD
LONDON SW7 2DE

IGS 2494 10 000 7/79

26 – 2. THF

WATER RESOURCES BOARD
WELL RECORD
SHEET 1

W.R.B. REF. No. SJ07/26
R.A. LICENCE No. 26/66/7/18/9

1. WELL IDENTITY

NATIONAL GRID REFERENCE SJ 008 778

Well at Moss Lodge Fm
I.G.S. REF. No.
RIVER AUTHORITY Dee & Clwyd
Town Rhuddlan
HYDROMETRIC AREA 66
County
SUB-CATCHMENT 7
Owner of well D. A. Hughes
Well made by
Date of sinking
Information from RA
Date received 5.8.68 Sms

2. WELL DESCRIPTION

Level of ground surface ..... m. If well top is not at above* ..... m.
above sea level (O.D.) ..... ft. ground level how far below ..... ft.

Shaft ..... m. / 60 ft. deep; Diameter at top ..... m. / ..... ft.; at bottom ..... m. / ..... ft.

Bore ..... m. / ..... ft. deep; Diameter at top ..... m. / ..... ft.; at bottom ..... m. / ..... ft.

Details of headings .....

DETAILS OF PERMANENT LINING TUBES

Length ..... m. / ..... ft.; Diam. ..... m. / ..... ft.; Plain ..... m. / ..... ft.; Slotted ..... m. / ..... ft.; Top ..... m. / ..... ft. above* / below surface

Length ..... m. / ..... ft.; Diam. ..... m. / ..... ft.; Plain ..... m. / ..... ft.; Slotted ..... m. / ..... ft.; Top ..... m. / ..... ft. above* / below surface

Length ..... m. / ..... ft.; Diam. ..... m. / ..... ft.; Plain ..... m. / ..... ft.; Slotted ..... m. / ..... ft.; Top ..... m. / ..... ft. above* / below surface

Details of well screen .....

DETAILS OF REST WATER LEVELS DURING CONSTRUCTION

Water struck at depths of ..... below well top

Rest level of water ..... m. / ..... ft. above* / below well top O.D.* when bore ..... m. / ..... ft. deep. Date

Rest level of water ..... m. / ..... ft. above* / below well top O.D.* when bore ..... m. / ..... ft. deep. Date

Rest level of water on completion of bore ..... m. / ..... ft. above* / below well top O.D.* when bore ..... m. / ..... ft. deep. Date

Method of drilling .....

Brief details of well development e.g. acid treatment etc. .....

* delete as applicable

(46452-1) 1

BGS BOREHOLE REFERENCE: SJ07NW108

Easting: 302060
Northing: 378000
Date: 1993
Length: 57.91m

56_1.TIF

Welsh L.S.
Welsh N.R.A.

SJ07/56

95

J.P.WHITTER

(WATER WELL ENGINEERS) LTD
LANGATE INDUSTRIAL ESTATE
WIGAN ROAD
BRYN WN4 0QZ
TEL: 0942 722706
24 HOUR: 0942 893660
FAX: 0942 719008

SJ07NW

RECORD OF BOREHOLE

NUMBER OF BOREHOLE: 180-7-93

BOREHOLE SUNK FOR: COUNTY LAUNDRY & CLEANERS (RHYL) LTD

ADDRESS OF BOREHOLE: STATION ROAD, RHUDDLAN, RHYL, CLWYD.

NATIONAL GRID REFERENCE: SJ 02067800

PURPOSE OF BOREHOLE: COMMERCIAL

DATE OF SINKING: MAY 1993

BOREHOLE SUNK BY: J.P.WHITTER (W/W ENG) LTD MACHINE: ~~TERBERG~~

INFORMATION FROM: UNIT 21, LANDGATE IND. EST., WIGAN ROAD, BRYN. LANCASHIRE. WN4 0QZ.

ADDITIONAL NOTES AND PUMP DETAILS:
32MT OF 6" PLAIN STEEL CASING
REST LEVEL OF WATER - 2MT.
PUMPING LEVEL - 6MT.
RECOVERED TO 2MT IN 4 HOURS 10MINS. TEST PUMPED AT 2,000GPH.
PUMP DEPTH - 30MT.

	DESCRIPTION OF STRATA		THICKNESS		DEPTH	
			METRE	FEET	METRE	FEET
	BACKFILL			1		0-1
Quaternary	GLACIAL DRIFT	[Estuarine Alluvium]		93		1-94
Permo-Triassic	SANDSTONE	[Lower Mottled Sandstone]		96		94-190.
					57.91m	

EUROPEAN OFFICES

AYLESBURY
T: +44 (0)1844 337380

BELFAST
belfast@slrconsulting.com

BIRMINGHAM
T: +44 (0)121 2895610

BONN
T: +49 (0)176 60374618

BRADFORD-ON-AVON
T: +44 (0)1225 309400

BRISTOL
T: +44 (0)117 9064280

CARDIFF
T: +44 (0)2920 491010

CHELMSFORD
T: +44 (0)1245 392170

DUBLIN
T: +353 (0)1 296 4667

EDINBURGH
T: +44 (0)131 335 6830

EXETER
T: +44 (0)1392 490152

FRANKFURT
frankfurt@slrconsulting.com

GRENOBLE
T: +33 (0)6 23 37 14 14

LEEDS
T: +44 (0)113 5120293

LONDON
T: +44 (0)203 8056418

MAIDSTONE
T: +44 (0)1622 609242

MANCHESTER
T: +44 (0)161 8727564

NEWCASTLE UPON TYNE
newcastle@slrconsulting.com

NOTTINGHAM
T: +44 (0)115 9647280

SHEFFIELD
T: +44 (0)114 2455153

SHREWSBURY
T: +44 (0)1743 239250

STIRLING
T: +44 (0)1786 239900

WORCESTER
T: +44 (0)1905 751310

Fferm Wynt Alltraeth

AWEL Y MÔR

Offshore Wind Farm

RWE Renewables UK
Swindon Limited

Windmill Hill Business Park
Whitehill Way
Swindon
Wiltshire SN5 6PB
T +44 (0)8456 720 090
www.rwe.com

Registered office:
RWE Renewables UK
Swindon Limited
Windmill Hill Business Park
Whitehill Way
Swindon