Awel y Môr Offshore Wind Farm

Category 6: Environmental Statement

Volume 5, Annex 7.6 A55 Trenchless Crossing Works HDD

Date: April 2022

Revision: A

Application Reference: 6.5.7.6

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

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A55 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

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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 A55 as part of the onshore 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 crossing of the A55 using HDD. 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 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 surrounding environment.

2.0 Study Area, Baseline Data and Methodology

2.1 Study area

The study area for the A55 crossing HDD crossing is shown on Figure 1. The HDD works for this location is c.1.5 km westwards of Llanelwy/ St Asaph, immediately westwards of a series of roundabouts and junctions which to the south lead to a collection of commercial and public sector buildings within St Asaph Business Park. Buffer zones of 250 – 500 m from the Order Limits that encompass the HDD working area have 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).

The extent of the proposed crossing is between the proposed trenchless crossing compounds to the north and south of the A55 respectively.

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 A55 crossing 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 A55 crossing 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 A55 crossing 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 A55 crossing 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 proposed A55 crossing HDD works are located c.1.5 km to the west of the densely populated town of Llanelwy / St Asaph. Continuing west along the A55 from the proposed HDD crossing point for c.1.25 km is the town of Bodelwyddan. Immediately to the east of the proposed HDD crossing point is a significantly extensive series of roundabouts and junctions. The St Asaph Business Park is found c.150 m south of the proposed crossing trenchless compound closest to the A55 and extends southwards. The extent of the proposed crossing is between the proposed trenchless crossing compounds to the north and south of the A55 respectively.

Apart from the St Asaph Business Park to the east, the land extending outwards away from the A55 between Bodelwyddan and Llanelwy/ St Asaph is predominately agricultural, low-lying land with a network of drainage ditches both westwards and eastwards; industrial, commercial and domestic properties are relatively sparse.

[1] Natural Resources Wales / Guidance on water discharges
[2] Environment Agency (April 2007) Hydrogeological Impact Appraisal for Dewatering Abstractions, Science Report – SC040020/SR1

Hedgerows and woodland are also relatively scarce and limited to field boundaries, although there is a small area of woodland eastwards of the series of roundabouts discussed above.

A site context plan is provided as Figure 1.

3.2 Geology

3.2.1 Soil and Superficial Deposits

The Cranfield Soil and Agrifood Institute Soilscapes online mapping service indicates that the proposed A55 crossing HDD works are wholly underlain by slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils.

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, it is indicated that diamicton till wholly underlies the proposed A55 HDD crossing works. Diamicton deposits extend for several kilometres westwards.

Tidal flat clay, silt and sand deposits are mapped c.1 km north of the proposed crossing, and these extend northwards towards the coastline. Alluvial deposits are mapped c.0.8 km east and relate to the Afon Clywd and its tributaries. They are deposited in a typically north-south alignment, and in the vicinity of Lllanelwy/ St Asaph vary in lateral extent from several hundred metres to over 1 km in width.

Historic BGS borehole records, as presented in Appendix 1, within the vicinity of the proposed A55 HDD crossing works indicate that glacial clay deposits are continuously present locally and typically comprise a sandy silty clay with some gravel and cobbles, with occasional bands of sand or sand and gravel. The depth of local logs is typically limited, but historic BGS borehole log SJ07NW19, located approximately 400 m to the north west indicates that the till extends to a depth of at least 20 m below ground. Other boreholes more than 1 km away indicate that the superficial deposits have been recorded up 35 m in thickness.

Superficial deposits are presented as Figure 2.

3.2.2 Bedrock

Bedrock at the proposed location for the A55 crossing HDD works is mapped by the BGS as mudstone, siltstone and sandstone of the Warwickshire Group. Limestone of the Clywd Limestone Group is mapped to occur c.350-400 m westwards of the proposed crossing location.

The Warwickshire Group is described as *'predominantly red, brown or purple-grey sandstone, siltstone and mudstone, some grey strata, coals not common, local conglomerates, localised beds of Spirorbis limestone'*. It is described as being over 1000 m in thickness in Warwickshire.

The Clywd Limestone Group is described as *'a diverse range of limestone facies with subordinate sandstone and mudstone units, and exhibiting local dolomitisation'*. Records detail the *'initiation and growth of a carbonate platform along the northern flank of the Wales-Brabant Massif'*.

Historic BGS borehole logs local to the site, as presented in Appendix 1, do not record the underlying bedrock.

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 A55 crossing HDD route recharge rates are likely to be relatively low, impeded by poorly draining clayey soils. These soils may promote surface water run-off to nearby watercourses and drains.

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
	Diamicton Till	Secondary (Undifferentiated)
Bedrock	Warwickshire Group	Secondary A

Deposit Type	Formation	Aquifer Designation
	Clwyd Limestone Group	Principal

The various classifications are described by NRW 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 diamicton till present at the HDD crossing area is classified as a secondary aquifer. However, it is considered that the clayey diamicton deposits will typically act as a barrier to significant groundwater flow.

Historic BGS logs indicate minor layers of higher permeability superficial deposits. Perched groundwater within superficial deposits is likely to typically be discontinuous and limited in extent and as such have limited groundwater potential.

Groundwater beneath the study area for this groundwater risk assessment is present within the Secondary A bedrock aquifer of Warwickshire Group. These deposits will typically comprise of cyclical layers of mudstones, sandstones and siltstones with some limestone bands. Groundwater flow will predominantly be within the higher permeability sandstone or limestone horizons. There is no information available as to the presence of any groundwater bearing horizons beneath the development area.

No information on groundwater level data is available in the immediate vicinity of the HDD crossing.

3.3.3 Abstractions

NRW and DCC has confirmed that there are no licensed or private abstractions within a 500 m radius of the A55 crossing HDD works. The closest licensed abstraction being 1.5 km to the north-north-east and one private water supply located 1.7 km to the east. Both are considered to be too remote from the works to be considered a potential receptor.

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.

The A55 crossing HDD works are located within the catchment of the Afon Clwyd, draining via a number of tributaries as detailed below. The Afon Clwyd is underlain by alluvium which overlies the till. These deposits do not extend beneath the A55 crossing and it is therefore unlikely that there will be any hydraulic connection with groundwater beneath the site.

Within the immediate vicinity of the A55 crossing area a series of surface water drains which typically flow in a predominantly northerly direction, these include the following drains:

3.4.1 Tyddyn Isaf Drain

Tyddyn Isaf Drain is a main river tributary of Sarn Drain (below) with a small upstream catchment that drains land including the area around the proposed HDD works. The alignment of the A55 ADD crossing will pass beneath the existing A55 culvert crossing for Tyddyn Isaf Drain.

The Tyddyn Isaf Drain is located within or directly adjacent to the currently proposed Order Limits including land for the A55 crossing HDD works.

3.4.2 Sarn Drain - East and West

Sarn Drain is served by a number of main river tributaries including, Sarn Drain East and Sarn Drain West and Tyddyn Isaf Drain (above). These tributaries tend to form approximately parallel channels which flow north from the A55 before joining the main Sarn Drain channel. Sarn Drain East is to the west the HDD crossing point, passing beneath the A55 c.450 m west of the HDD alignment.

3.4.3 Pengwern Drain

Pengwern Drain is a main river flowing from south to north to the east of the proposed HDD crossing, passing beneath the A55 to the east of Princes Gorse woodland. .

Pengwern Drain is located c.600 m eastwards of the proposed HDD works.

3.4.4 Non-main river watercourses

There are a number of existing field drains, ditches and irrigation channels within the study area for these works. A number of these non-main river watercourses to the north of the proposed HDD crossing appear to form tributaries to the watercourses detailed above. To the south a number of these non-main river watercourses come together to pass into the Tyddyn Isaf Drain culvert beneath the A55. These features are detailed in Figure 4.

These watercourses are located on low permeability deposits and are therefore considered to have limited groundwater baseflow component.

3.4.5 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 3-3-.

The A55 crossing HDD works are within an assessed WFD Cycle 2 (2018 Interim) river waterbody area. They are within the Point Robin Cut River Waterbody Catchment Area.

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

River Waterbody Catchment	WFD Cycle 2 (2018 Interim) Status		
	Ecological	Chemical	Overall
Pont Robin Cut	Poor	Good	Poor

The A55 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.

3.5 Ecologically Designated sites

There are no ecologically designated sites within a 500 m radius of A55 crossing HDD works. With consideration to the limited aquifer potential of the underlying superficial deposits, local wildlife sites over a kilometre south of the site are not considered to be dependent on groundwater at the proposed HDD crossing location.

3.6 Conceptual Site Model Summary

The assessment of the baseline conditions of the A55 crossing HDD crossing works indicate that the proposed crossing area is underlain by a Secondary A aquifer, the Warwickshire Group Formation, which has the potential to provide moderate groundwater yields from sandstone or limestone horizons, although there is no indication of any abstractions from the strata within the vicinity of the A55 crossing HDD works.

Within the vicinity of the trenchless crossing works the bedrock is overlain by over 20 m of low permeability superficial deposits. The superficial deposits have the potential for limited groundwater flow within any sandy and gravel horizons, however these tend to be variable and unconnected and are therefore unlikely to provide significant flows for either abstractions within the wider area or surface water baseflow.

Given the thickness of the superficial deposits it is unlikely that the HDD works will encounter bedrock strata.

Due to the low permeability of the superficial deposits, there is considered to be no hydraulic connection between groundwater within either the superficial or bedrock deposits and surface watercourses.

No groundwater dependent ecological sites are identified within the study area.

4.0 Hydrogeological and Hydrological Impact Assessment

4.1 Proposed Development

A description of the proposed HDD activity at the A55 crossing area 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 and surface water 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.

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 Secondary A 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 flow to either surface water or ecological receptors.

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

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.

In the event that groundwater within the Warwickshire Group Formation 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 Warwickshire Group Formation aquifer is low.

4.1.5 Impact on groundwater quality from drilling mud

Drilling mud is used as part of the HD 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 a voids in the aquifer a connected via the drilling. Drilling will however primarily take place through the superficial till deposits which are dominated by clays and silts which will limit the potential for any migration of bentonite away from the drill hole.

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 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 limited groundwater baseflow from the study area due to the low permeability of the superficial deposits likely

acting to limit the rate and volume of groundwater flows. 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, groundwater within the bedrock aquifer will potentially be confined beneath the low permeability superficial deposits at a depth of more than 20m below ground level, it is therefore unlikely that the proposed works will directly encounter bedrock groundwater. There is some limited potential that the HDD crossing will encounter groundwater from the underling bedrock where this is in continuity with gravels and sands at the base of the overlying superficial deposits. Some perched groundwater is potentially present within layers of sand and gravel superficial deposits; however, the typically low permeability of the till mean that 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 the overall impact on flows is likely to be negligible to low owing to the very small size of the opening in relation to the aquifer and the lack of any nearby significant receptors which could be impacted by what would be a very localised radius of influence. Based on a sensitivity of medium the overall significance of effect is assessed as minor and no further mitigation above that embedded in the design is considered necessary

4.1.8 Impact on Groundwater Abstractions and Ecological Sites

There are no recorded nearby abstractions or designated ecological sites that are considered to be in hydraulic connection with the proposed HDD crossing. Given that it is not anticipated that the works will directly impact the bedrock aquifer and the pollution prevention measures which will be put into place the potential for adversely impacting abstractions or ecological sites at distance is assessed as negligible.

5.0 Conclusions

A groundwater risk assessment has been undertaken to assess the potential impact of the proposed A55 crossing HDD Crossing Works on groundwater receptors.

The assessment has indicated that the primary potential receptor of concern relates to groundwater within the underlying bedrock aquifer. Abstractions within the town of St Asaph are not considered to be in hydraulic connection with the proposed HDD crossing.

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 bedrock 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 low as the works will be entirely within the superficial deposits. 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 both groundwater and surface water will be 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].

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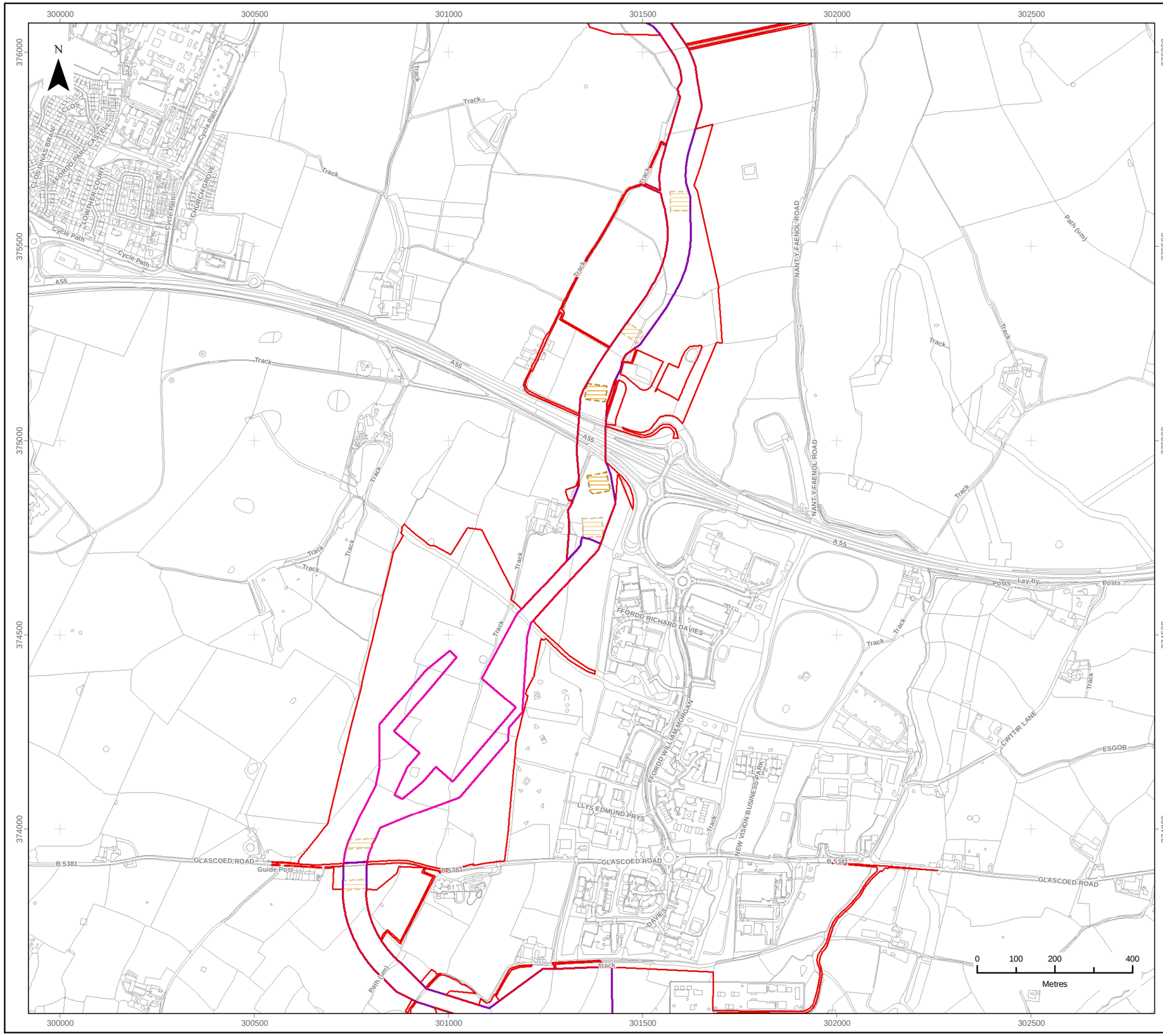

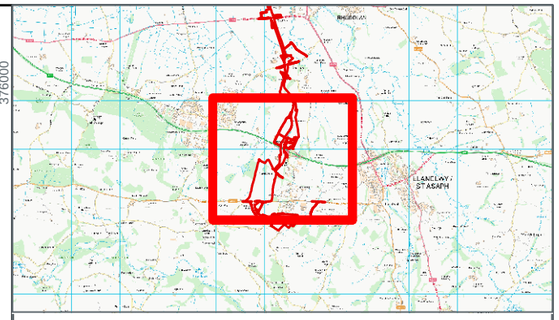

LEGEND

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

Data Source:
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PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A55 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

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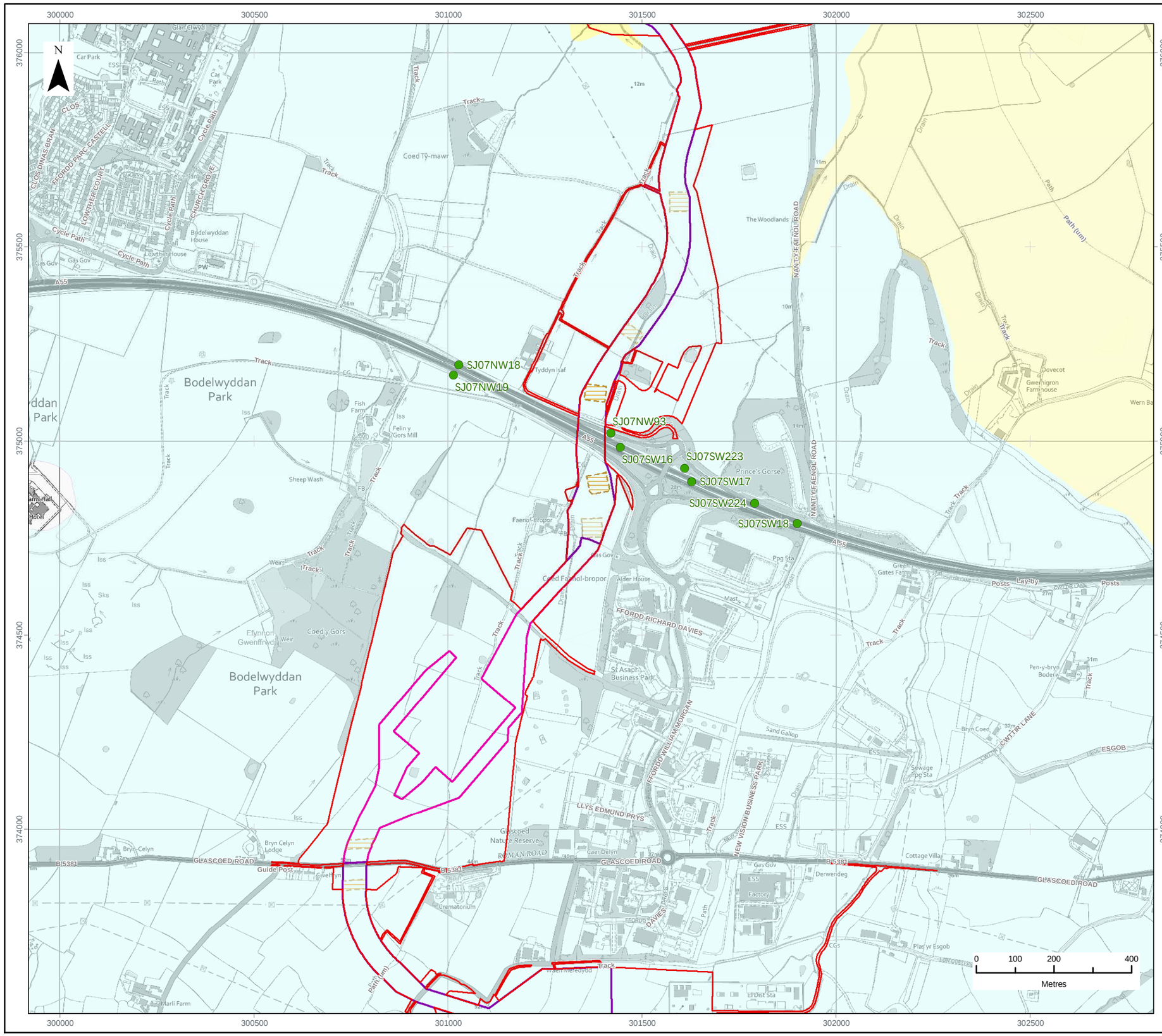

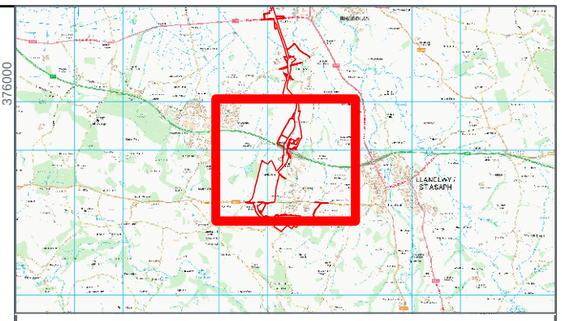

LEGEND

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

Superficial Geology

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

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A55 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

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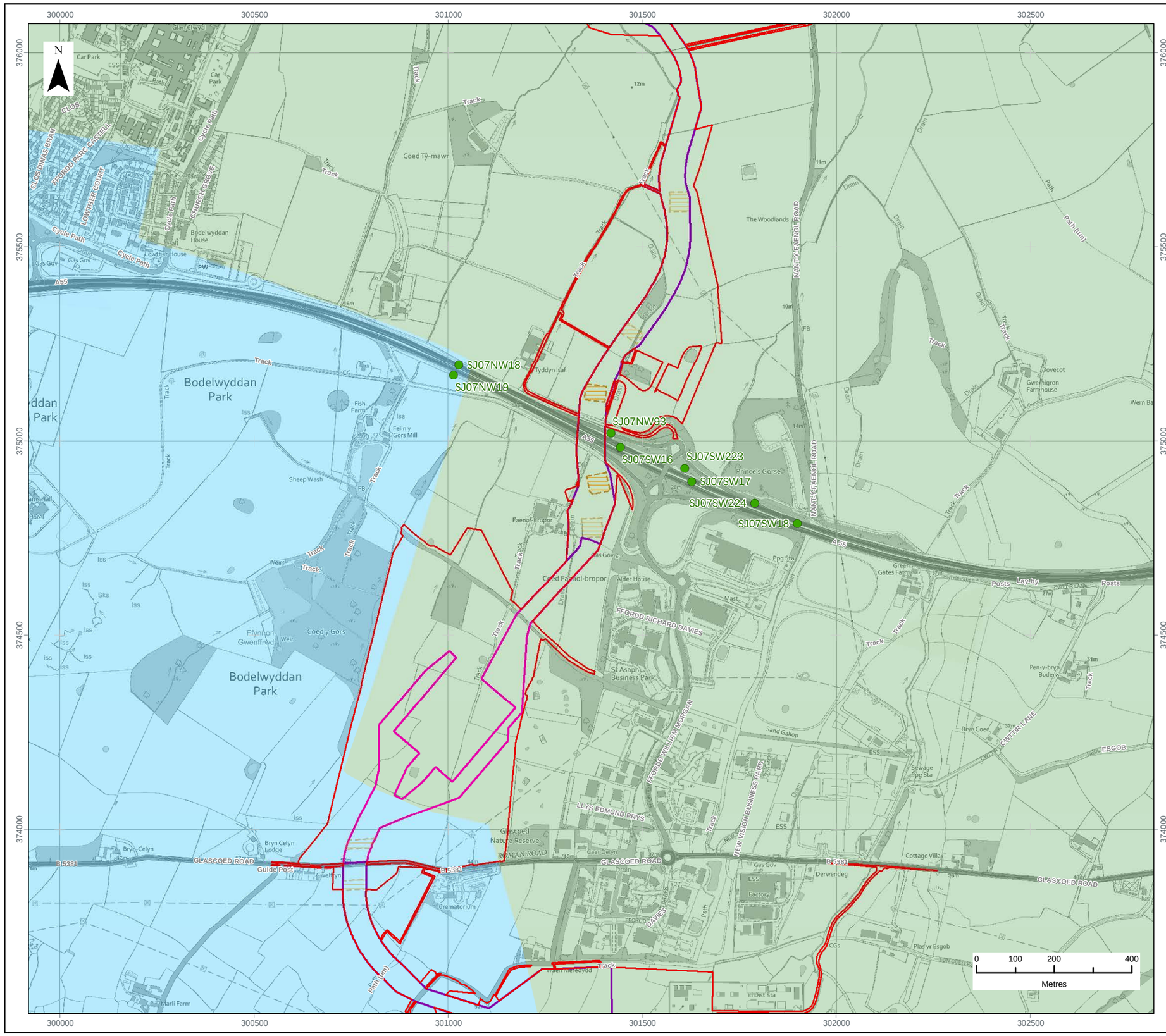

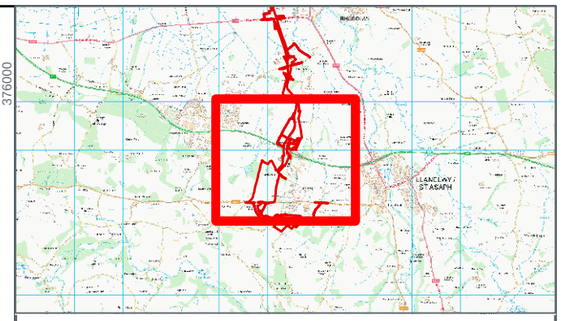

LEGEND

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

Bedrock Geology

- Warwickshire Group - Mudstone, Siltstone And Sandstone (Carboniferous-Permian)
- Clwyd Limestone Group - Limestone (Carboniferous)
- Historic BGS Borehole

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A55 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

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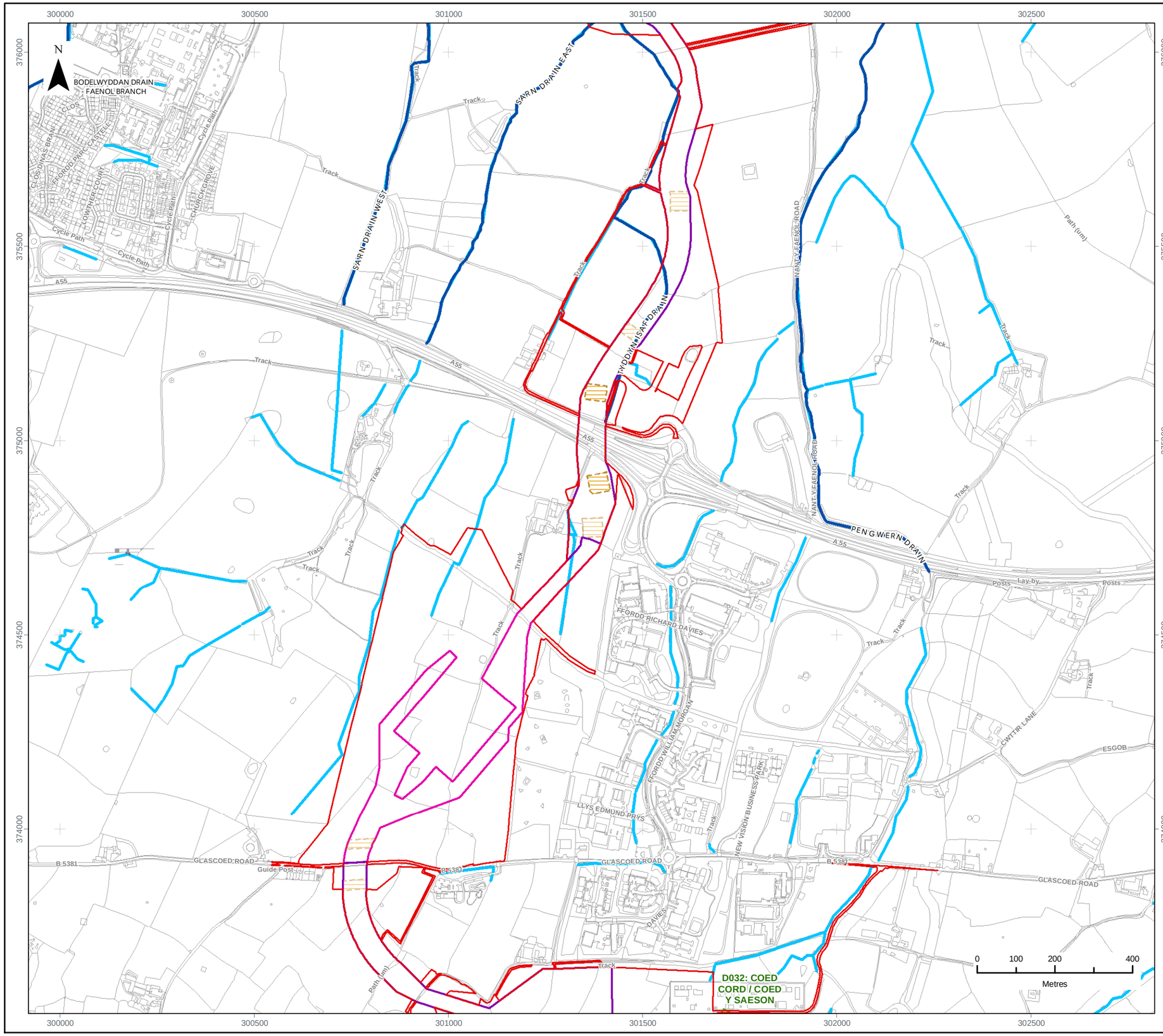

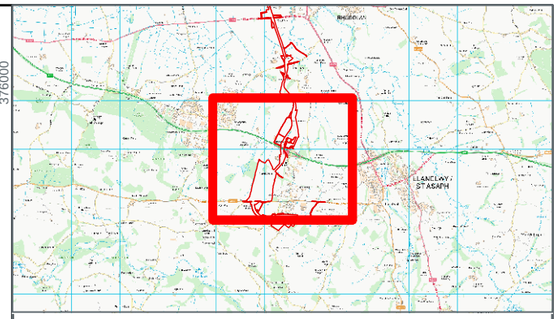

LEGEND

- Order Limits
- Proposed Onshore Export Cable Corridor
- Proposed Substation Cable Corridor Zone
- Proposed Trenchless Crossing Compound
- Local Wildlife Site
- NRW Main River
- Ordinary Watercourse

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

PROJECT TITLE:

AWEL Y MÔR OFFSHORE WINDFARM

A55 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

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BGS BOREHOLE REFERENCE: SJ07NW18

Easting: 301028
Northing: 375196
Date: -
Length: 12.00m

Site Investigation at St. Asaph Job 3242

Type of equipment Pilcon Wayfarer

Diameter of hole 8" (200mm)

LOG OF BOREHOLE No. B1

SJ07NW/18

01028 75196 1"107

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	SAMPLING DATA: DEPTH TO	SAMPLING DATA: No.	SAMPLING DATA: TYPE	LEGEND	CHANGE OF STRATA: DEPTH	CHANGE OF STRATA: REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	GROUND LEVEL: 18.21m O.D.
	8.11.72				0.25	1	D				TOPSOIL - brown silty CLAY with some sand & roots
					0.40	2	D		0.35	17.93	STIFF brown silty CLAY with a little medium sand
				0.50	0.95	3	U4				to medium gravel (Glacial Clay)
1 m											
					1.25	4	D				
2 m											
			2.00	2.00	2.45	5	U4				
3 m					2.75	6	D				-----brown with grey patches
			3.50	3.50	3.95	7	U4				-----VERY STIFF
4 m											
					4.25	8	D				
5 m	8.11.72	DRY	5.00								
	9.11.72	DRY	5.00	5.00	5.45	9	U4				-----FIRM
6 m					5.75	10	D				
			6.50	6.50	6.95	11	U4		7.00	11.28	-----becoming VERY STIFF
7 m					7.25	12	D				HARD grey sandy silty CLAY with some
8 m											medium sand to fine gravel (Boulder Clay)
			8.00	8.00	8.45	13	U4				
9 m					8.75	14	D				
			9.50	9.50	9.95	15	U4				.....becoming VERY STIFF
10 m											
		(a)			10.25	16	D				
11 m											
					11.30	17	D				------with abundant layers and pockets of yellow
12 m	9.11.72	DRY	11.50 11.50	11.55	12.00	18	U4		12.00	6.28	fine to medium sand.
											End of Borehole
13 m											

Key

	sampling depth, soils
U4	4 in. dia. undisturbed sample (102 mm)
U3	3 in. dia. undisturbed sample (73 mm)
D	disturbed jar sample
B	disturbed bulk sample
W	water sample
SP ( )	standard penetration test
CP ( )	cone penetration test
(25)	number of blows e.g. 25
•	no recovery
80	core drilling, 80% recovery
RQD	rock quality designation

Notes

a) Seepage at 10.20m

BGS BOREHOLE REFERENCE: SJ07NW19

Easting: 301014
Northing: 375170
Date: -
Length: 20.00m

Site investigation at: St. Asaph — Job: 3242 — LOG OF BOREHOLE No. B2

Type of equipment: Pilcon Wayfarer

Diameter of hole: 8" (200mm)

SJ07NW/19

01014 75170 1"107

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	DEPTH TO	No.	TYPE	LEGEND	CHANGE OF STRATA: DEPTH	REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	GROUND LEVEL: 18.65m O.D.
	3.11.72				0.20	1	D		0.35	10.30	TOPSOIL - brown silty CLAY with some sand and roots
					0.40	2	D				
				0.50	0.95	3	U4				VERY STIFF brown silty CLAY with a little fine
1 m											gravel. (Glacial Clay)
					1.25	4	D				
2 m											
				2.00	2.45	5	U4				.....becoming STIFF and sandy
					2.75	6	D				
3 m											
				3.50	3.65	7	U4(a)				
4 m				4.00	4.45	8	U4				
5 m					4.75	9	D				
	3.11.72	DRY	5.50								
	4.11.72	DRY	5.50	5.50	5.95	10	U4		5.75	12.90	
6 m		(b)			6.20	11	D				HARD grey sandy silty CLAY with some
											medium sand to medium gravel and cobbles.
7 m				7.00	7.45	12	U4				(Boulder Clay)
8 m					8.00	13	D				
				8.50			U4*				
9 m											
			9.00	9.00	9.45	14	U4				
10 m					9.75	15	D				
			10.50	10.50	10.95	16	U4				
11 m											
		(d)		11.55	12.00	17	U4				
12 m	4.11.72	DRY	12.00								
	6.11.72	10.60	12.00		10.60	18	W				
									12.5	6.15	
					12.60	19	D				VERY DENSE brown silty fine SAND with pockets of clay.
13 m											

Continued on next sheet

Key

	sampling depth, soils
U4	4 in. dia. undisturbed sample (102 mm)
U3	3 in. dia. undisturbed sample (73 mm)
D	disturbed jar sample
B	disturbed bulk sample
W	water sample
SP ( )	standard penetration test
CP ( )	cone penetration test
(25)	number of blows e.g. 25
•	no recovery
80	core drilling, 80% recovery
RQD	rock quality designation

Notes

(a) U4 at 3.50m, only 150mm recovery.

(b) Water struck at 6.05m

(c) SP test at 16.50m; 33 blows for seating drive, then 63 blows for 150mm penetration.

(d) Standpipe installed at 12.00m with gravel from 11.00 to 12.00m

(e) SP test at 19.75m, 44 blows for seating drive, then 41 blows for 75mm penetration.

R1. NUTTALL GEOTECHNICAL SERVICES LTD.

BOREHOLE B2

Job 3242

Site Investigation at St. Asaph Job 3242

LOG OF BOREHOLE No. B2

(Continuation Sheet)

SJ07NW/19

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	DEPTH TO	No.	TYPE	LEGEND	CHANGE OF STRATA: DEPTH	REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	Continued from previous sheet
				13.05	13.50	20	D, SR(57)		13.40	5.25	DENSE brown gravelly fine to medium SAND, gravel fine to medium
14m				14.00	14.50	21	B				MEDIUM DENSE rounded fine to coarse GRAVEL with a little sand and some clay.
	6.11.72	12.00	14.50								
15m	7.11.72	6.30		15.00	15.45	22	CP(26)		15.50	3.35	
					15.70	23	D				VERY STIFF grey gravelly sandy silty CLAY - gravel fine to medium (Boulder Clay)
16m											
				16.50	16.95	24	D, SP(c)				
17m											
18m											
	7.11.72	6.10	18.00		18.00	25	D				
	8.11.72	6.20	18.00								
19m											
20m	8.11.72	6.00	19.50	19.75	20.00	26	D, SP(e)		20.00	-1.35	End of Borehole
	9.11.72	2.05	in standpipe								
21m	1.11.72	4.70									
	3.11.72	4.58									
	25.11.72	6.65									
	27.11.72	4.70									
22m	28.11.72	4.65									
	7.12.72	flooded									
	14.12.72	3.00									
	21.12.72	3.00									
23m	28.12.72	flooded									
	5.1.73	3.00									
	11.1.73	3.00									
	18.1.72	3.00									
24m											
25m											
26m											
27m											
28m											
29m											
30m											

For Key to symbols and Notes, see first sheet for this borehole.

BOREHOLE B2

NUTTALL GEOTECHNICAL SERVICES LTD.

Job 3242

BGS BOREHOLE REFERENCE: SJ07NW93

Easting: 301420
Northing: 375020
Date: 1979
Length: 4.50m

SJ07NW 93

NDC GEOTECHNICAL CONSULTANTS	BORING METHOD(S) CABLE PERCUSSION	BOREHOLE No 47
	MACHINE(S) PILCON 1500 (200mm)	SHEET No 1 of 1
CONTRACT BODELWYDDAN BY-PASS		CHAINAGE 0142 OFFSET CUT/FILL 7502

Daily Progress		Samples and In situ Tests		Ground Level 18.40m AOD			DESCRIPTION OF STRATA
Date	Ground Water	Levels B.G.L.	Type	Symbol	Depth	OD Level	
29.8.79							MADE GROUND
		0.50	U				Very stiff yellow brown very sandy silty clay with scattered fine gravel and organic root fibr
		1.00	J				
‖		1.50	U		1.50	16.90	
		2.00	J				
		2.50	U				Very stiff changing to stiff with depth reddish brown silty slightly sandy CLAY with scattered grey silt veins and occasional fine gravel.
		3.00	J				
		3.50	U				
		4.00	J				
4.5m	Nil				4.50	13.90	
							End of Borehole.

REMARKS

Cased from G.L. to 1.50 metres B.G.L.

Key U=Undisturbed Sample J=Hand Samples B=Bulk Sample ‖=Casing Level
W=Ground Water Sample N=S/CPT 'N' Values ▽=Water First Met

REPORT No 159/N/489

BGS BOREHOLE REFERENCE: SJ07SW16

Easting: 301444
Northing: 374984
Date: 1963
Length: 4.48m

Site Investigation at St. Asaph Job 3242

Type of equipment Pilcon Wayfarer

Diameter of hole 8" (200 mm)

LOG OF BOREHOLE No. 8

SJ07SW/16

01444 74984 1"107

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	DEPTH TO	No.	TYPE	FIELD TESTS	CHANGE OF STRATA: DEPTH	REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	GROUND LEVEL 18.86m O.D.
	1.11.72				0.20	1	D				
					0.40	2	D		0.30	18.56	TOPSOIL - brown silty CLAY with sand and roots
				0.50	0.95	3	U4				VERY STIFF brown with patches of grey sandy silty
1 m											CLAY with a little fine gravel (Glacial Clay)
					1.25	4	D				
2 m											
				2.00	2.45	5	U4				
3 m											
					2.75	6	D				
				3.55	4.00	7	U4(a)				
4 m				3.55		8	D				.....becoming STIFF
				4.05	4.50	9	U4				
	1.11.72	DRY	4.00	-					4.50	14.36	End of Borehole
5 m											
6 m											
7 m											
8 m											
9 m											
10 m											
11 m											
12 m											
13 m											

Key

▨	sampling depth, soils
U4	4 in. dia. undisturbed sample (102 mm)
U3	3 in. dia. undisturbed sample (73 mm)
D	disturbed jar sample
B	disturbed bulk sample
W	water sample
SP ( )	standard penetration test
CP ( )	cone penetration test
(25)	number of blows e.g. 25
•	no recovery
▨ 80	core drilling, 80% recovery
RQD	rock quality designation

Notes

(a) U4 at 3.55m, only 75mm recovery, retained in jar 8.

BOREHOLE 8

R1. NUTTALL GEOTECHNICAL SERVICES LTD. Job 3242

BGS BOREHOLE REFERENCE: SJ07SW17

Easting: 301628
Northing: 374896
Date: -
Length: 3.96m

Site Investigation at St. Asaph Job 3242

Type of equipment Pilcon Wayfarer

Diameter of hole 8" (200mm)

LOG OF BOREHOLE No. 9

SJ07SW/17

01628 74896 1"107

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	DEPTH TO	No.	TYPE	LOG END	CHANGE OF STRATA: DEPTH	REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	GROUND LEVEL 20.11m O.D.
	1.11.72				0.20	1	D				TOPSOIL - silty CLAY with sand and roots
					0.40	2	D		0.30	19.81	STIFF brown, with patches of grey silty CLAY
1 m				0.50	0.95	3	U4				with pockets of white silt and a little sand to fine
					1.25	4	D				gravel (Glacial Clay)
2 m											
				2.00	2.45	5	U4				.....becoming VERY STIFF and fissured
3 m											
					2.75	6	D				
4 m	1.11.72	DRY	1.50	3.55	4.00	7	U4		4.00	16.11	.....becoming STIFF
											End of Borehole
5 m											
6 m											
7 m											
8 m											
9 m											
10 m											
11 m											
12 m											
13 m											

Key

▨	sampling depth, soils
U4	4 in. dia. undisturbed sample (102 mm)
U3	3 in. dia. undisturbed sample (73 mm)
D	disturbed jar sample
B	disturbed bulk sample
W	water sample
SP ( )	standard penetration test
CP ( )	cone penetration test
(25)	number of blows e.g. 25
*	no recovery
▩ 80	core drilling, 80% recovery
RQD	rock quality designation

Notes

BOREHOLE 9

RI. NUTTALL GEOTECHNICAL SERVICES LTD. Job 3242

BGS BOREHOLE REFERENCE: SJ07SW18

Easting: 301900
Northing: 374788
Date: -
Length: 6.00m

Site Investigation at St. Asaph Job 3242

Type of equipment Pilcon Wayfarer

Diameter of hole 8" (200mm)

LOG OF BOREHOLE No. 10

SJ 07 SW/18

0190 74788 1"107

DEPTH SCALE	DAILY PROGRESS	DEPTH TO WATER	DEPTH OF CASING	SAMPLING DATA: DEPTH FROM	SAMPLING DATA: DEPTH TO	SAMPLING DATA: No.	SAMPLING DATA: TYPE	LEGEND	CHANGE OF STRATA: DEPTH	CHANGE OF STRATA: REDUCED LEVEL	DESCRIPTION OF STRATA
		m	m	m	m				m	m	GROUND LEVEL: 19.40m O.D.
	31.10.72				0.20	1	D		0.25	19.15	TOPSOIL - light brown silty CLAY with roots and pockets of white silt
					0.50	2	D		0.55	18.85	Concrete and angular gravel
					0.65	3	D				VERY STIFF brown, with grey patches, silty CLAY
1 m				0.80	1.25	4	U4				with a little sand to fine gravel and traces of carbonaceous matter near top (Glacial Clay)
2 m					1.95	5	D				
				2.30	2.75	6	U4				-----fissured
3 m					3.20	7	D				
4 m				3.80	4.25	8	U4				-----becoming VERY STIFF/HARD and fissured
5 m				-	4.80	9	D				
				5.55	6.00	10	U4				-------becoming HARD
6 m	31.10.72	DRY	1.50						6.00	13.40	End of Borehole
7 m											
8 m											
9 m											
10 m											
11 m											
12 m											
13 m											

Key

▨	sampling depth, soils
U4	4 in. dia. undisturbed sample (102 mm)
U3	3 in. dia. undisturbed sample (73 mm)
D	disturbed jar sample
B	disturbed bulk sample
W	water sample
SP ( )	standard penetration test
CP ( )	cone penetration test
(25)	number of blows e.g. 25
•	no recovery
▮ 80	core drilling, 80% recovery
RQD	rock quality designation

Notes

BOREHOLE 10

R1. NUTTALL GEOTECHNICAL SERVICES LTD. Job 3242

BGS BOREHOLE REFERENCE: SJ07SW223

Easting: 301610
Northing: 374930
Date: 1979
Length: 3.30m

SJ07SW 22

NDC GEOTECHNICAL CONSULTANTS

BORING METHOD(S)	CABLE PERCUSSION	BOREHOLE No 49
MACHINE(S)	PILCON 1500 (200mm)	SHEET No 1 of 1

CONTRACT BODELWYDDAN BY-PASS

CHAINAGE 0161
OFFSET
CUT/FILL 7493

Daily Progress		Samples and In situ Tests		Ground Level 20.83m AOD			DESCRIPTION OF STRATA
Date	Ground Water	Levels B.G.L.	Type	Symbol	Depth	OD Level	
29.8.79		0.30	U		0.30	20.53	TOP SOIL.
		0.80	J				Very stiff changing to hard reddish brown silty slightly sandy CLAY with grey silt veins and occasional fine to coarse gravel.
		1.30	U				
‖		1.80	J				
		2.30	U				
		2.80	J				
3.3m	Nil	3.30	U		3.30	17.53	End of Borehole.

REMARKS

Cased from G.L. to 1.50 metres B.G.L.

Key U=Undisturbed Sample J=Hand Samples B=Bulk Sample ‖=Casing Level
W=Ground Water Sample N=S/CPT 'N' Values ▽=Water First Met

REPORT No 159/N/489

BGS BOREHOLE REFERENCE: SJ07SW224

Easting: 301790
Northing: 374840
Date: 1979
Length: 3.75m

SJ07SW 22

NDC GEOTECHNICAL CONSULTANTS

BORING METHOD(S)	CABLE PERCUSSION	BOREHOLE No 51
MACHINE(S)	DANDO 150 (200mm)	SHEET No 1 of 1
		CHAINAGE 0179
CONTRACT BODELWYDDAN BY-PASS		OFFSET
		CUT/FILL 7484

Daily Progress		Samples and In situ Tests		Ground Level 19.87m AOD			DESCRIPTION OF STRATA
Date	Ground Water	Levels B.G.L.	Type	Symbol	Depth	OD Level	
29.8.79							Stiff brown sandy silty CLAY.
		0.50	U		0.50	19.37	
‖							Hard to very stiff becoming stiff with depth reddish brown silty CLAY with scattered grey silt veins and occasional fine gravel (brown organic root fibres near top). Becoming less silty and with less gravel with depth.
		1.25	J				
		1.50	U				
		2.00	J				
		2.50	U				
		3.00	J				
		3.25	U				
3.75m	Nil				3.75	16.12	
							End of Borehole.

REMARKS Cased from G.L. to 1.00 metre B.G.L.

Key U=Undisturbed Sample J=Hand Samples B=Bulk Sample ‖=Casing Level
W=Ground Water Sample N=S/CPT 'N' Values ▽=Water First Met

REPORT No 159/N/489

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