10 GEOLOGY, SOILS AND CONTAMINATED LAND

10.1 Introduction

10.1.1 This Chapter of the Environmental Appraisal identifies the potential impacts of the Proposed Project on geology, soils and contaminated land as well as the potential impacts of the geology, soils and contaminated land on the Proposed Project.

10.1.2 With respect to contaminated land, the appraisal explores potential effects on human health, controlled waters (groundwater and surface water), property and the environment from the presence or mobilisation of existing contaminants, or from accidental release of contaminants during the construction, operational or decommissioning phases of the Proposed Project.

10.1.3 Potential effects on geology, soils and contaminated land are interrelated with effects on surface water and land use. This Chapter should be read in conjunction with Chapter 2: Project Description, Chapter 6: Landscape and Visual, Chapter 7: Ecology, Chapter 8: Archaeology and Cultural Heritage, Chapter 9: Water Resources and Chapter 11: Agriculture and Land Use, of this Environmental Appraisal. Chapter 9 discusses the potential for the Proposed Project to impact nearby surface waters; whereas this Chapter (10) discusses the potential for the Proposed Project to impact groundwater and discusses surface waters only where they may be impacted via a groundwater pathway.

10.2 Scope and Methodology

The Study Area

10.2.1 For the purposes of this appraisal the following terms of reference are used and shown on Figure 10.1:

- Study Area for Permanent and Temporary Works – used for the basis of the Study Area for the purposes of baseline data collection. At the outset of the Proposed Project the Study Area for Permanent and Temporary Works formed the maximum extent (potential land take) of the Proposed Project taking into consideration all potential engineering options.
- Study Area – For data collection purposes the Study Area for this Chapter has adopted the boundary of the Study Area for Permanent and Temporary Works (shown as blue line on Figure 10.1) for environmental baseline data collection and historical mapping review. Receptors are considered within the Study Area. The Study Area has been chosen for this environmental appraisal as it incorporates the most relevant potential receptors that may be impacted by (including sensitive environments, surface water and groundwater resources) and activities that may have an impact on the Proposed Project (including historical development at the site and in the surrounding area, potentially contaminative permitted activities and waste operations).
- Site Boundary – The boundary of the Proposed Project; encompassing all temporary and permanent works (shown as red line on Figure 10.1).

Methodology

10.2.2 A qualitative desk-based appraisal has been undertaken using information held in the public domain and information collected to inform the engineering design. This has been supplemented by a site visit / walkover. This was used to develop a conceptual site model and preliminary risk assessment based on the likelihood and severity of an impact. The assessment of the magnitude of potential effects has been made using both legislative processes and statutory policies and guidance, in the case of geomorphology

and hydrogeology (Table 10-3) and professional judgement, in the case of impact to human health from contamination. This appraisal has been carried out in accordance with current regulations, guidance and best practice, including but not limited to:

- Land Contamination Risk Management (LCRM[1]) guidance document which is currently under consultation for feedback;
- Design Manual for Roads and Bridges: Volume 11, Section 3 Environmental Assessment Techniques, Part 10: LA113 (formerly HD 45/09) Road Drainage and the Water Environment (Highways Agency 2009);
- Design Manual for Roads and Bridges: Volume 11, Section 3 Environmental Assessment Techniques, Part 11: HD 213/11 Geology and Soils (Highways Agency 2011); and
- Planning Policy Wales: Welsh Government, Planning Policy Wales, Edition 10 December 2018.

10.2.3 The appraisal involved:

- A review of current legislation, planning policy and guidance in relation to the effects of the Proposed Project on the hydrogeological, geological environment and sensitive receptors;
- A desk study data review and walkover survey to establish the environmental setting and existing hydrogeological and geological baseline conditions. The desk study included review of site-specific information obtained from an environmental database search provided by GroundSure, consultations with statutory bodies and other stakeholders, and project specific ground investigation data collected by WSP | Parsons Brinckerhoff (WSP);
- Preparation of a Preliminary Risk Assessment (PRA) and an initial Conceptual Site Model (CSM) to identify plausible pollutant linkages (PPL);
- Evaluation of the potential effects of the Proposed Project on the geological and hydrogeological environment and other sensitive receptors;
- Identification of embedded mitigation and avoidance measures which will be incorporated into the Proposed Project;
- Review of the potential sources of contamination in relation to receptors through plausible pathways;
- Assessment of the sensitivity of receptor and magnitude of potential impacts;
- Identification of measures to mitigate against potentially adverse impacts; and,
- Assessment of residual impacts following mitigation.

10.2.4 The baseline assessment within this appraisal takes into consideration the sources of possible contamination and the presence of plausible pathways to receptors. This method is used to identify plausible pollutant linkages (PPL), if present, broadly in line

[1] Land Contamination: Risk Management. https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks, Environment Agency, June 2019. The Environment Agency released this guidance in June 2019 to update the Environment Agency/DEFRA Contaminated Land Report Model Procedures for the Management of Land Contamination (CLR11), to which it is largely similar. CLR11 was intended to be withdrawn 6 months after the release of the LCRM guidance.

within Part 2A of the Environmental Protection Act 1990[2] and based on the assessment process set out in CLR 11[3] and LCRM.

10.2.5 As part of the appraisal a site walkover was undertaken over the publicly accessible parts of the Study Area on the 14th and 15th of August 2019, including a visual assessment of safely accessible surface water features, topographic features, exposed geology and soils. The purpose of the site walkover was to:

- Note features of geological, geomorphological and hydrogeological interest;
- Review the hydrological characteristics of the Study Area;
- Assess the topography of the Study Area;
- Assess the potential for ground instability within the Site Boundary for the Proposed Project; and,
- Assess the local environmental setting and nature of potential receptors (including local residents and site users).

Sources of Information

10.2.6 Sources of information are as follows in Table 10.1.

Table 10.1: Sources of Information

Policy Documentation	
Welsh Government, Planning Policy Wales, Edition 10 December 2018	Gwynedd Council, Anglesey and Gwynedd Joint Local Development Plan 2011 – 2026 Written Statement 31 July 2017, viewed September 2019
Snowdonia National Park / Parc Cenedlaethol Eryri Local Development Plan 2016 - 2031 adopted February 2019, viewed September 2019.	Building Research Establishment, 2005. Special Digest 1: Concrete in aggressive ground, Third edition. BRE Construction Division.
Publicly Available Resources	
Natural Resources Wales public register EPR Permits and Water Resource Licences. https://nrwregulatory.naturalresources.wales/Permits Viewed September 2019	Natural Resources Wales Geo-Portal for wales http://lle.gov.wales September 2019.
Natural Resources Wales Free of	Zetica (2018) UXO risk maps. Available via:

[2] Defra (April 2012) Environmental Protection Act 1990: Part 2A. Contaminated Land Statutory Guidance.

[3] Environment Agency/DEFRA. 2004. Contaminated Land Report Model Procedures for the Management of Land Contamination (CLR11). 2004

Publicly Available Resources	
Charge Coal Mining Information https://www.gov.uk/guidance/using-coal-mining-information Viewed September 2019	http://zeticauxo.com/downloads-and-resources/risk-maps/. Viewed September 2019.
Coal Authority Map Viewer. Available via: http://mapapps2.bgs.ac.uk/coalauthority/home.html. Viewed September 2019	Defra MAGIC Map Application. Available via: https://magic.defra.gov.uk/MagicMap.aspx. Viewed September 2019
British Geological Survey GeoIndex. http://mapapps2.bgs.ac.uk/geoindex/home.html. Viewed September 2019	Google Earth. imagery dated 06/02/2016. Viewed September 2019
British Geological Survey Lexicon of Named Rock Units. Available via: http://www.bgs.ac.uk/Lexicon/. Viewed September 2019	British Geological Survey Geology of Britain Viewer. Available via: http://mapapps.bgs.ac.uk/geologyofbritain/home.html. Viewed September 2019
UK Soil Observatory Soils Map Viewer. Available via: http://mapapps2.bgs.ac.uk/ukso/home.html. Viewed September 2019	Natural Environment Research Council (2017) and Centre for Ecology and Hydrology (CEH). GeoIndex interactive mapping. Available online via: http://mapapps2.bgs.ac.uk/geoindex/home.html?submit=Open+the+onshore+GeoIndex. Viewed September 2019
Project Specific Documents	
GroundSure Enviro Insight Report (Ref: AEC_TC_04_04_19_Enviro) dated 11th April 2019	GroundSure Geo Insight Report (Report Reference: AEC_TC_04_04_19_Geo) dated 11th April 2019
Geotechnical Desk Study Report Work Package 3:, Ref: 70019952/2 (April 2016)	Visual Impact Provision Feed Snowdonia Factual Ground Investigation Report, Ref: 70032995 (April 2018)
Interpretative Geo-environmental Report Snowdonia National Park, Ref: Pdd-33494-Rep-013 (May 2018)	Snowdonia VIP (Visual Impact Provision) Cable Tunnel Geotechnical Baseline Report, Ref: 0032995 (November 2018)

Determining the Sensitivity and Magnitude of Potential Impacts

10.2.7 The criterial used to define the sensitivity (or value) of a receptor and the magnitude of potential impact (change) are based on principles outlined within DMRB Volume 11[4]. The criteria to define the sensitivity of a receptor and the magnitude of potential impact on a receptor in relation to this Chapter are shown in Table10.2 and Table 10.3.

Table10.2: Sensitivity / Value of the Receptor

Sensitivity / Value	Criteria	Feature / Receptor / Resource	Indicator of Quality
High	Medium national and high regional importance with limited potential for replacement	Hydrogeology	- Principal Aquifer - Principal aquifer providing locally important resource or supporting river ecosystem - (SPZ) 2 – Outer protection zone
		Geomorphology	- For contaminated land this would relate to a 'moderate risk' [5] - Site of local geological importance (e.g. Local Geological Site, Sites of Special Scientific Interest (SSSI))
Medium	Low regional and high local importance with some potential for replacement	Hydrogeology	- Secondary Aquifer - Aquifer providing water for agricultural or industrial use with limited connection to surface water - (SPZ) 3 – Source catchment protection zone
		Geomorphology	- For contaminated land this would relate to a 'low risk'. - Mineral Safeguarding Area
Low	Local importance with potential for replacement	Hydrogeology	- Unproductive strata
		Geomorphology	- Undesignated sites with little local geological/ soils interest. - For contaminated land this would relate to a 'very low risk'.
Very Low	Very low importance and rarity, local scale	Hydrogeology	- Unproductive strata
		Geomorphology	- Undesignated sites with no local geological/soils interest. - For contaminated land this would relate to a 'very low risk'.

[4] Highways Agency (2009) Design Manual for Roads and Bridges: Volume 11, Section 3 Environmental Assessment Techniques, Part 10: HD 45/09 Road Drainage and the Water Environment (Highways Agency 2009)

[5] broadly in line within Part 2A of the Environmental Protection Act 19905 and based on the assessment process set out in LCRM

Table 10.3: Magnitude of Potential Impact (Change)

Magnitude	Criteria	Resource	Typical Examples
Major Adverse	Results in loss of receptor and/ or quality and integrity of the receptor	Hydrogeology	- Loss of, or extensive change to, an aquifer - Potential high risk of pollution to groundwater - Loss of, or extensive change to, groundwater supported designated wetlands
		Geomorphology	- Loss/sterilisation of the resource and/or quality and integrity of resource; severe damage to important characteristics, features or elements.
Moderate Adverse	Results in effect on integrity of receptor, or loss of part of receptor	Hydrogeology	- Partial loss or change to an aquifer - Potential medium risk of pollution to groundwater - Partial loss of the integrity of groundwater supported designated wetlands
		Geomorphology	- The site's integrity will not be adversely affected, but the Proposed Project may lead to a loss of or damage to important characteristics, features or attributes or partial sterilisation.
Minor Adverse	Results in some measurable change in receptor quality or vulnerability	Hydrogeology	- Potential low risk of pollution to groundwater - Minor effects on groundwater supported wetlands
		Geomorphology	- A measurable minor negative impact on important characteristics, features or attributes is evident.
Negligible	Results in effect on receptor, but of insufficient magnitude to affect the use or integrity	Hydrogeology	- No measurable impact upon an aquifer and risk of pollution from spillages
		Geomorphology	- Minor alteration to one or more characteristics, features or elements or no observable impact
Minor Beneficial	Results in some beneficial effect on receptor or a reduced risk of negative effect occurring	Hydrogeology	- Calculated reduction in existing spillage risk by 50% or more to an aquifer (when existing spillage risk <1% annually)
		Geomorphology	- A measurable minor positive impact on important characteristics, features or attributes is evident.

Magnitude	Criteria	Resource	Typical Examples
Moderate Beneficial	Results in moderate improvement of receptor quality	Hydrogeology	- Calculated reduction in existing spillage risk by 50% or more (when existing spillage risk is >1% annually)
		Geomorphology	- A moderate positive impact on important characteristics, features or attributes is evident.
Major Beneficial	Results in major improvement of receptor quality	Hydrogeology	- Removal of existing polluting discharge to an aquifer or removing the likelihood of polluting discharges occurring - Recharge of an aquifer
		Geomorphology	- A major positive impact on important characteristics, features or attributes is evident.

10.2.8 The appraisal has defined the potential impacts of the Proposed Project. The assessment of potential impacts takes account of embedded mitigation measures and good practice construction techniques (as incorporated into an Outline Construction and Environmental Management Plan (OCEMP)) into account. Temporary effects are considered in the construction phase.

Limitation on Assessment / Uncertainties

10.2.9 A door to door Private Water Supply (PWS) / water features survey has not been conducted as part of this assessment. However, Gwynedd County Council were consulted with regards to PWS, and a number of PWS / water features were identified within the Study Area.

10.2.10 Where any conclusions and suggestions contained in this Chapter are based upon information provided by other organisations, it has been assumed that all such information is accurate and correct.

10.2.11 A site inspection was undertaken from publicly accessible highways and public rights of way. Areas not visible from publicly accessible land could not be visually inspected. Only external features of buildings and facilities were recorded as part of the site walkover. While the location and nature of surface water features were observed as part of the site walkover, further investigation and detailed assessment is provided within Chapter 9: Water Resources.

10.3 Consultations Undertaken

10.3.1 As part of the scoping phase of the Environmental Appraisal, a Screening and Scoping Report[6] was prepared. This report set out the proposed approach to undertaking the Environmental Appraisal in respect of the Proposed Project, including the identification of appraisal methodologies for each of the topic areas. The information and advice received during the scoping process with regard to geology, soils and contaminated land (including waste) is presented within the Scoping Report.

10.3.2 As part of this appraisal, consultation was undertaken with relevant bodies with respect to geology, soils and contamination. This included the data and information requests as listed in Table 10.

[6] National Grid (2018) 'Visual Impact Provision: Snowdonia National Park, Overhead Line 4ZC Screening & Scoping Report October 2018'.

Table 10.4: Consultation Responses Geology, Soils and Contaminated Land

Date	Consultee	Summary of Issues	Section where comment addressed
25 February 2019	Natural Resources Wales	Response 5 March 2019 - No information is held by Natural Resources Wales outside of their interactive mapping on their website.	Incorporated into Chapter 10
25 February 2019	Gwynedd Council	Response 1 March 2019 - Gwynedd Council have provided a mixture of tables and images outlining the Private water supplies, historic landfill sites, potentially contaminated land and Part B permits within the site boundary.	Incorporated into Chapter 10

10.4 Statutory and Planning Context

10.4.1 Legislation and policy relevant to this geo-environmental appraisal have been considered on an international, national, regional and local level.

10.4.2 A summary of these documents in relation to this appraisal is provided within Appendix 10A.

10.5 Existing Environment

10.5.1 The Study Area encompasses a portion of the Dwyryd Estuary within a valley oriented east north east to west south west including land on either side.

10.5.2 For the purpose of this appraisal and to assist in the review, the Study Area has been divided into a number of sub-areas, as shown on Figure 10.1. These sub-areas are divided largely by location and overall ground conditions.

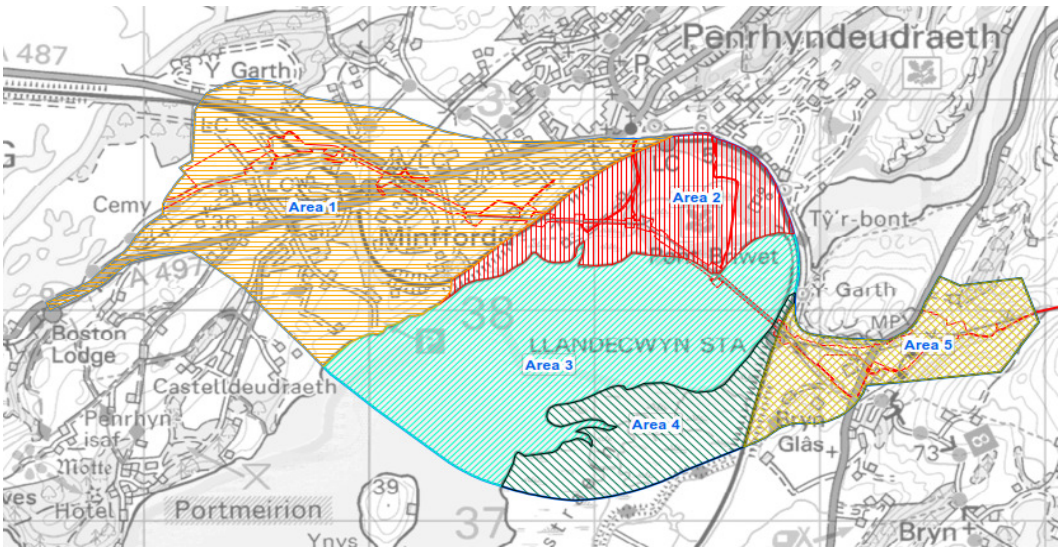
10.5.3 For consistency, the 'Areas' utilised in this appraisal are broadly similar to the 'Zones' utilised for the purpose of geotechnical review by WSP first noted in their Geotechnical Desk Study Report (Geotechnical Desk Study Report Work Package 3: Snowdonia National Park, Ref: 70019952/2 (April 2016)). However, as the Study area differs to that outlined within WSP reports, to avoid confusion, with those 'Zones', the sub-divisions within this Chapter are classified as 'Area 1' through to 'Area 5' outlined below:

- Area 1: Minffordd & Penrhyndeudraeth
- Area 2: Northern 'Saltmarsh'
- Area 3: Tidal Estuary
- Area 4: Southern 'Saltmarsh'
- Area 5: Llandecwyn

10.5.4 The valley sides broadly form Area 1 (the terrestrial land north and west) and Area 5 (the terrestrial land south and east). The valley narrows towards the east where the estuary starts to close as it leaves the Study Area and widens out to the west as the estuary broadens towards Porthmadog and the coast. Within the base of the valley the topography flattens out into the two saltmarshes, Area 2 (north saltmarsh) and Area 4 (south saltmarsh). The boundary between the saltmarshes and the estuary is defined by the mean high water springs. The estuary (Area 3) is shallow with outcropping sand banks.

10.5.5 A plan of the Study Area and its divisions is presented within Figure 10.1. An extract is presented below:

Plate 10.1: The Study Area and its Divisions



10.5.6 The Study Area covers a very large area in comparison to the Site Boundary and a large portion of the Proposed Project is at depth, below ground level. This appraisal focuses on those features within the Study Area that are considered directly relevant to the Proposed Project. As such, it should be noted that not all features within the Study Area shall be discussed within this appraisal. Where a specific feature is considered of relevance to the Proposed Project and is within close proximity to the Site Boundary, it shall be followed by a note in square brackets' [*Explanatory note*] '.

10.5.7 The following section is informed by the site walkover as well as supporting publicly available information, and the Enviro Insight and Geo Insight GroundSure reports obtained for the Study Area.

Historical Mapping Review

10.5.8 A detailed review of historical mapping dating between 1888 and 2014 with relation to this Chapter has been undertaken and is presented in Appendix 10B and a detailed summary is provided below. An archaeological review of historic mapping is also provided in Chapter 8: Archaeology and Cultural Heritage.

10.5.9 The Study Area has remained largely unchanged since the earliest historic mapping of 1888 with the Afon Dwyryd, its associated saltflats and estuary, dominating the centre of the Study Area and the land to the north and south being predominantly open presumed pastoral land with the exception of the two towns of Minffordd and Penrhyndeudraeth and the main roads, railways and associated rail stations.

10.5.10 The A467 Porthmadog bypass was constructed in October 2011 [Running along the northern boundary of the Site Boundary for the western pylon (4ZC037, 4ZC036 and 4ZC035 removal areas, and the cable tunnel alignment].

10.5.11 The towns of Minffordd and Penrhyndeudraeth have gradually expanded over the years: Minffordd predominantly to the south; and Penrhyndeudraeth predominantly to the south west. At the southern end of Minffordd an old quarry was noted in 1913 and present until it was residentially developed by 1977.

10.5.12 Garth Quarry, straddling the north western end of the Study Area, is currently in operation and has been present since before 1888. The quarry expanded notably

between 1913 and 1949. The Maenofferen Slate Quarry Co. yard and rail sidings in Minffordd has also been present since before 1888 and is connected by rail to the Quarry. The yard is still present but appears disused with the main building onsite being noted as a hostel on recent Google mapping [close to the southern side of the western infrastructure area].

10.5.13 Snowdonia Business Park, located between Minffordd and Penrhyndeudraeth, was constructed between 1977 and 2002 and the associated school was constructed later, between 2010 and 2014.

10.5.14 The Snowdonia National Park Office was built between 1977 and 1995 to the north east of the business park. The disused Bron Y Garth Hospital building to its north west was formerly a workhouse from before 1888 and an operating hospital up to 1974. The hospital was still named on mapping until after 2010. An 'old quarry' was noted to the immediate north of the hospital, noted from 1913 to between 1960 and 1977 and is currently noted as rough pasture.

10.5.15 An Explosives Works was present to the immediate north east of the Study Area adjacent to the road and Network Rail railway which form the border of Area 2. The works were present from 1872 to 1995 (demolished by 1997). Noted on the mapping as a 'works' with a cluster of buildings identified as an Explosives Works and a few areas to its north east noted as 'magazines'. After 1916 and before 1977 the works had expanded notably with many buildings across a large area to the south, east and north of the original site including a pump house, tanks, a tramway, subway and overhead cranes / aerial ropes. The site was clear by the 2002 mapping.

10.5.16 At the time of the expansion of the Explosives Works a filter bed tank was noted within the Study Area (Area 2) on the western side of the railway line opposite the Explosives Works. By 1995 the site of the filter beds had expanded into a sewage works which is present currently.

10.5.17 A second Welsh Water site was noted within Area 5, adjacent to pylon 4ZC027, from between 1960 and 1975 until present day. The site is understood to comprise both a sewage works and a Water Treatment Facility and underwent expansion from 2010 [located immediately south of the Site Boundary].

10.5.18 A third sewage works was noted at the approximate location of the western tunnel shaft in Area 1 from between 1960 and 1972 through to before 1995 when it was no longer noted on the mapping [on the site of the proposed western tunnel shaft and head house].

Site Walkover Observations

10.5.19 The following sections break down the observations by Area:

Area 1

10.5.20 Area 1 covers approximately 1.62km^2. Area 1 is crossed by two main roads, the A497 which forms the western end of the Area of Study Area, and the A487 which crosses Area 1 broadly west to east. Two railway lines also cross Area 1, these are the Network Rail line from Shrewsbury to Pwllheli and the Ffestiniog Railway from Porthmadoc to Blaenau Ffestiniog.

10.5.21 Area 1 has a variable topography rising from the estuary up to a long ridge running south west to north east on which the towns of Minffordd and Penrhyndeudraeth lie. From this high point to the north west of Minffordd, the topography lowers to a relatively flat area [Where the western infrastructure area is anticipated during the tunnel construction & cable installation] leading to the lowlands of another valley associated with the Afon Glaslyn to the north west. The streams in this north western area broadly flow north west to the Afon Glaslyn rather than south to the Afon Dwryrd.

10.5.22 The exception to the topography of the land north of Minffordd is the area around a quarry, located immediately north of Minffordd (Garth Quarry), where the topography undulates but generally rises towards the cliff faces into which the quarry cuts. With the exception of the Garth Quarry, outcropping rock is less prevalent within Area 1 than Area 5 on the south eastern side of the estuary.

10.5.23 Area 1 comprises a large section of the towns of Minffordd and Penrhyndeudraeth including residential and commercial properties which lie within the Study Area, as well as an out of town business park including a school. The other main features in Area 1 include:

- Garth quarry;
- Railway stations, including maintenance yard / sidings;
- Former hospital building;
- Former Maenofferen Slate Quarry Co yard (hostel and rail sidings);
- Current operational sewage works [adjacent to the Site Boundary];
- Small garages and works; and
- Existing substations pylons and associated infrastructure.

10.5.24 Outside of the towns and features above, the majority of Area 1 comprises open agricultural land with the predominant use being for sheep and cattle grazing. The ground is typically rough pasture with ponding surface waters in lowland areas [Where the western infrastructure area is anticipated during the tunnel construction & cable installation].

Areas 2 and 4

10.5.25 On either side of the estuary is open rough grazing land currently used for sheep grazing (described as saltmarshes). These areas are intersected by an intensive network of drainage channels and tidal inlets. The channels crossing through these areas are approximately 1m to 2m deep, typically reaching the height of the estuary waters and are likely to be tidally influenced and dependent upon salt or fresh water input. Wooden bridges are present in a number of locations to allow access to the land and the pylons in these areas. Alluvial deposits in these areas were exposed and comprised soft, unstable material. The saltmarshes comprise a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC).

10.5.26 The main features noted within Areas 2 and 4 are:

- The current OHL and Pylons crossing the estuary;
- The foundations of the former Pylon 4ZC030 in Area 2;
- The roadway and railway line with an associated bridge, Pont Briwet, along the eastern boundary of the Areas; and
- A small sewage works adjacent to the roadway within Area 2.

10.5.27 Outside the Study Area to the east, a number of small commercial / industrial units along the road over the estuary were noted, including vehicle garages and commercial suppliers.

Area 3

10.5.28 Area 3 comprises the Afon Dwyryd and associated estuary below the high water mark of ordinary tides (HWMOT). The area comprises shallow tidal waters with many silt/ sand islands and banks. The nature and locations of the banks and islands are likely to shift

within the estuary over time. The estuary comprises a Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC).

Area 5

10.5.29 Area 5 forms the eastern most extent of the Study Area and is separated from Area 4 by the Network Rail railway line. Area 5 broadly follows the low-lying areas of a steep valley oriented west to east with prolific large rock outcrops on either side forming the majority of the Area boundary to the north and south east. The valley base rises steeply towards the eastern end of Area 5 and the overhead lines run west to east along the base of the valley in this area.

10.5.30 The Network Rail embankment forms the western boundary to Area 5, separating the reclaimed pasture in Area 5 with the saltmarsh (Area 4). The A496 crosses Area 5. To the west of the A496 is a small Water Treatment Works. [immediately south of Pylon 27].

10.5.31 To the west of the A496, where the topography is flatter, the land comprises rough grazing land for sheep.

10.5.32 To the east of the A496 the land is water-logged with mire/peat habitat but rises steeply where it is covered in dense gorse, ferns, and bushes with friable rock outcrops.

10.5.33 The Nant Yr Efail river flows down the valley from the north east to the west towards the estuary, passing beneath the A496 via a small culvert north of the water treatment works, and then extending along the northern boundary of Area 5, where it passes beneath road and railway culverts to discharge into the estuary. [This area is where the water discharge for the shaft dewatering is anticipated for the eastern shaft].

Published Geology

Soils

10.5.34 Within the estuary and adjacent land (Areas 2, 3, 4 and part Area 5), soils are identified as Saltmarsh soils[7], described as; lime rich but saline, loamy soils. The Saltmarsh soils are classed as deep, heavy soils described as clay to silt, typical of a marine/ estuarine parent material. This area is typically shown as marshy land on the Ordnance Survey mapping.

10.5.35 Beyond the estuary, the soils noted within the Study Area comprise freely draining acidic loamy soils. These acidic loamy soils are noted as intermediate to shallow soils categorised as medium to light on the south side of the estuary and medium to heavy on the north side, split by a medium to light (silty) band broadly following the presence of sandstone bedrock strata. Bedrock is likely to be very shallow or exposed.

10.5.36 The BGS Soil Chemistry datasets detail the topsoil concentrations of five potentially harmful elements (PHEs): Arsenic (As), Cadmium (Cd), Chromium (Cr), Nickel (Ni) and Lead (Pb). Elevated concentrations of these PHEs can exist because of natural geological conditions or possible human contamination. According to the GroundSure Geo Insight Report commissioned for the Proposed Project (here on referred to as the GroundSure Report) the following BGS estimated soil chemistry levels are attributed to the Study Area:

- Arsenic: Highly variable across the Study Area <15-120 mg/kg;
- Cadmium: <1.8 mg/kg;
- Chromium: 60-90 mg/kg;

[7] UK Soil Observatory Soils Map Viewer. http://mapapps2.bgs.ac.uk/ukso/home.html. Viewed 22/11/18.

- Nickel: Typically <15-30 mg/kg, (with 15 of 570 records within the Study Area noting 30-45 mg/kg): and,
- Lead: Typically <100mg/kg, 17 of 570 records within the Study Area noting 100-200 mg/kg.

Made Ground

10.5.37 The GroundSure Report identified four areas of 'artificial ground' (made ground) within the Study Area, from the 1:50,000 BGS scale mapping.

10.5.38 A review of the current and historic mapping and the GroundSure Report indicates that these relate to:

- An area of artificial ground is present in Minffordd at the location of the Maenofferen Slate Quarry yard with former rail sidings. The quarry appears disused. [south east of the western infrastructure];
- An area associated with the existing Garth SEC north of Minffordd [at Garth SEC around its western and northern sides];
- An area entering the northern part of Area 1 along the A487 which appears to be associated with the edge of the Breedon Minffordd (Garth) Quarry which extends into the Study Area;
- A small refuse tip north of the Porthmadog Bypass to the north of Bron Turner Cottage. The tip area is mostly within the Study Area with the remainder and access track outside of the area extending to the north. The tip currently appears to be disused.

10.5.39 While made ground is not denoted within the remainder of the Study Area, areas of made ground are likely to be present across the Study Area associated with both current and historic operations and developments, specifically the former sewage works in Area 1 [at the western tunnel head house area] and Area 2 and reclaimed land in Area 5.

Peat

10.5.40 Areas of peat have the potential to contain highly compressible organic soil. In addition, they also have the potential to contain significant amounts of water. As well as being a consideration in terms of construction, peatland habitats are important as a nature conservation resource and in wider respects in terms of their importance relating to carbon storage and sequestration.

10.5.41 The Proposed Project has been purposely developed to avoid peat wherever possible although does underly the eastern section of the Site Boundary.

10.5.42 BGS records indicate that small areas of peat may be present sporadically to the north east of Minffordd. Peat is identified across the wider area in small pockets. A peat survey has been undertaken for the Proposed Project, the results of which are included within the Peat Management Plan (appendix to the Outline CEMP).

Superficial Geology

10.5.43 According to available published data[8] and the GroundSure Report, the presence of superficial deposits is sparse over much of the Study Area, with the exception of the Dwyryd Estuary and the estuary margins. A map of the superficial geology is presented in Figure 10.2.

[8] BGS Geology of Britain Viewer. http://mapapps.bgs.ac.uk/geologyofbritain/home.html. Viewed September 2019.

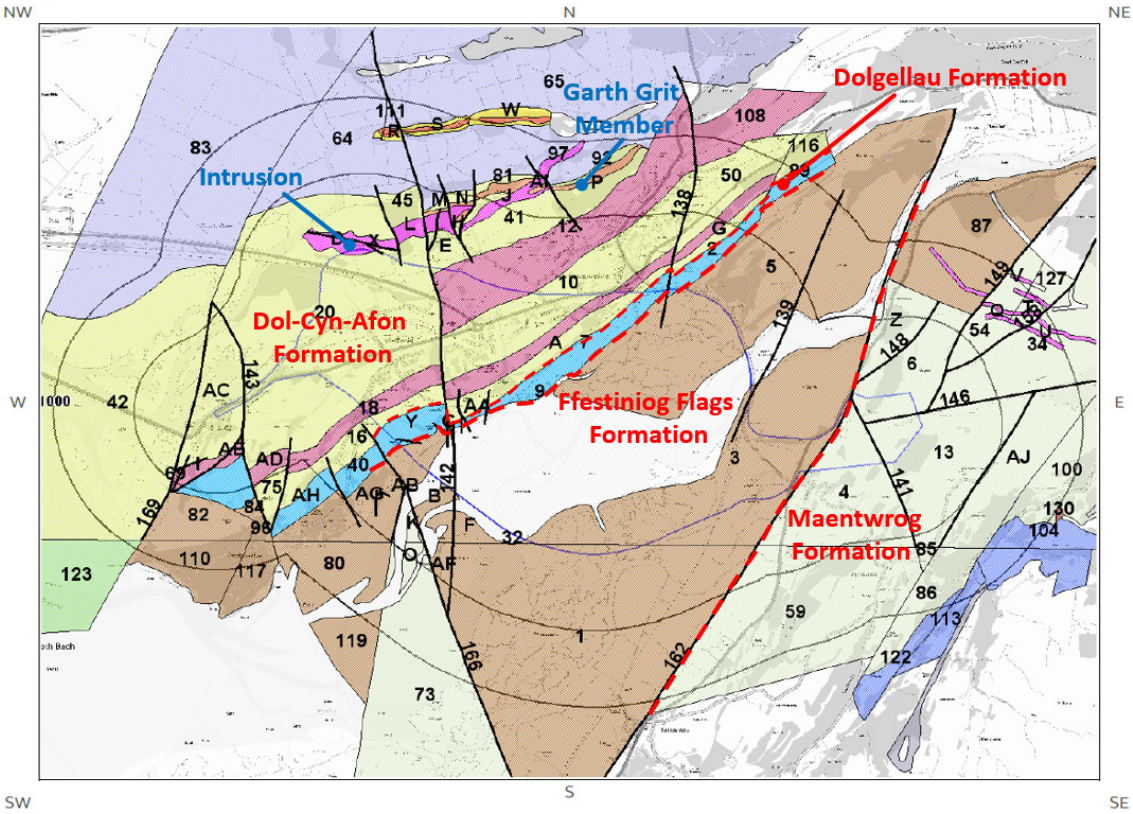
10.5.44 The north western portion of the Study Area is recorded to be underlain by alluvium, which is described as being normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger desiccated surface zone may be present. To the north of the Porthmadog and Minffordd Bypass (A487), and to the in the vicinity of the A487 in the east, the area is underlain by head/polymict deposits, comprising gravel, sand and clay, locally with lenses of silt, clay or peat and organic material, depending on the upslope source and distance from source. They comprise poorly sorted and poorly stratified deposits formed mostly by solifluction and/or hillwash and soil creep. A broadly linear area of peat is recorded stretching from Minffordd, north east to Penrhyndeudraeth.

10.5.45 The recorded deposits along the Dwyryd Estuary comprise Tidal Flat deposits of clay, silt and sands, with shifting sands noted. Comparison of online aerial photographs and Ordnance Survey 1:25,000 mapping indicates that the main estuary channel, downstream of the recently re-constructed Pont Briwet bridge, has changed considerably, with the more recently mapped deep water channel coinciding with the location of former Pylon 4ZC030. These Tidal Flat deposits extend further east and south east of the estuary broadly covering the majority of the eastern section of the Study Area, extending up to and beyond the A496 in the east of Area 5. The Tidal Flat deposits extend around the base of Y Garth hill, broadly following the low-lying ground along the valley floor. Higher / steeper areas on the valley sides are noted as being devoid of recorded superficial deposits.

Solid (Bedrock) Geology - Strata

10.5.46 According to available published data, bedrock beneath the Study Area from west to east comprises the following (also presented on Figure 10-3 by lithology and by name in the GroundSure Geo Insight report an extract of which is presented below).

Plate 10.2: Marked up Extract of Bedrock Geology from the Geo Insight Report



10.5.47 The bedrock underlying, and in the vicinity of, the Study Area generally comprises mudstones, siltstones and sandstones of the Mawddach Group. An igneous intrusion is noted in the north western extent of the Study Area with numerous igneous intrusions noted outside of the Study Area to the north and east and further to the west.

10.5.48 Broadly, the Study Area comprises the Maentwrog Formation, recorded within the eastern end of the Study Area (Area 5), progressing westwards along the cable tunnel alignment the geology changes in line with a series of faults, to the Ffestiniog Flags Formation which underlies the Dwyryd Estuary. The Dolgellau Formation abuts the north western edge of the estuary beyond which the Dol-Cyn-Afon Formation makes up the majority of the underlying geology of the western end of the Study Area. All the strata are shown by the BGS as dipping steeply in a generally northerly direction (BGS, 1997).

10.5.49 The western side of the Dwyryd Estuary, within the Study Area, is underlain predominantly by the Dol-Cyn-Afon Formation (Mudstone and Siltstone). This typically comprises grey mudstone, and silty mudstone and siltstone, with bio-turbated sandstones locally. The Dol-Cyn-Afon Formation (Sandstone) is reported to be present within the eastern section of the Study Area.

10.5.50 The igneous intrusion within the Study Area is unnamed by the BGS but described as a microgabbro of Ordovician age. The igneous intrusion is recorded within the Dol-cyn-Afon Formation and extends into the north western end of the Study Area, crossing the Garth (Minffordd) Quarry. The intrusion is oriented west to east, trending towards south west to north east at its eastern end to the north of the Study Area. The intrusion in places passes through the Garth Grit Member of interbedded Sandstone and Conglomerate, which are noted adjacent to the intrusion.

10.5.51 The Dolgellau Formation is recorded crossing the site on a south west to north east orientation on the north western edge of the estuary, following in part the Network Rail railway line. The Dolgellau Formation is described as Cambrian Mudstones and Siltstones, bound to the north west (and overlain by) the Dol-cyn-afon Formation, and bound to the south east (and underlain by) the Ffestiniog Flags Formation.

10.5.52 The eastern / south eastern section of the Study Area to the east of the Network Rail railway line (south of the Dwyryd Estuary) is, in its majority, recorded to be underlain by the Ffestiniog Flags Formation (Mudstone, Siltstone and Sandstone), which is generally comprised of regular alternating beds of quartzose siltstone and sandstone in beds up to 2m thick, interbedded with silty mudstone. Abundant sedimentary structures are present. The Ffestiniog Flags Formation extends northwards across the estuary.

10.5.53 At the eastern end of the Study Area, to the east of the A496, the bedrock is identified as the Maentwrog Formation (Mudstone, Siltstone and Sandstone), which is recorded as generally comprising interbedded mudstones, coarse-grained sandstones and fine-grained turbiditic sandstones. Within this formation there are numerous recorded igneous intrusions of Ordovician age further to the east; these are recorded as microgabbro.

Solid (Bedrock) Geology - Structure

10.5.54 The Study Area and wider geology is heavily faulted and generally dips downwards towards the north west, as part of the southern arm of a large syncline fold broadly trending south west to north east. An inferred north to south trending fault crosses the north western portion of the Study Area, approximately crossing Minffordd Railway Station, and another inferred fault crossing north to south through Penrhyndeudraeth Railway Station with other inferred faults shown adjacent to and within the northern and eastern extents of the Study Area. The bedrock formations present spatially as bands oriented north east to south west across the Study Area ranging from the youngest rocks to the north west, to the oldest within the south east.

10.5.55 The WSP Geotechnical Baseline Report, prepared to inform the engineering design, identifies this dip to be an approximate 20 to 40 degrees to the north west as identified within the mudstone bedding recorded during the WSP ground investigations along the cable tunnel alignment. This syncline dominates the wider area as part of the energetic regional geology of the Snowdonia region including large scale faulting, folding and intrusions.

10.5.56 The GroundSure Report and BGS website mapping identified at least 16 No. faults crossing the Study Area, typically on a north east to south west alignment. The GroundSure mapping and geological mapping indicates two main faults crossing the Study Area, one in Area 1 north of the Afon Dwyryd and one to the south of the Afon Dwyryd in Area 5. The WSP Geotechnical Baseline Report identified from the ground investigation and local mapping, that four faults cross the cable tunnel alignment, the one on the north side of the Afon Dwyryd noted on the geological mapping and three on the southern side of the Afon Dwyryd one of which is the one captured on the mapping.

Ground Conditions Data from Previous Investigations

10.5.57 In addition to publicly available borehole logs through the British Geological Survey website (www.bgs.ac.uk) AECOM has been provided with four reports and available data produced by WSP for the VIP Snowdonia Project.

10.5.58 The WSP reports include a geotechnical desk study from 2016, factual and interpretive reports from April and May 2018 for a ground investigation undertaken between 29th of August 2017 and the 22nd of December 2017, and a baseline report from November 2018 which summarises the geotechnical findings of the three prior reports and the findings of a second phase investigation from between May and September 2018.

10.5.59 The reports are listed below:

- Geotechnical Desk Study Report Work Package 3: Snowdonia National Park, Ref: 70019952/2 (April 2016).
- Visual Impact Provision Feed Snowdonia Factual Ground Investigation Report, Ref: 70032995 (April 2018).
- Visual Impact Provision: Interpretative Geoenvironmental Report Snowdonia National Park, Ref: Pdd-33494-Rep-013 (May 2018).
- Snowdonia VIP (Visual Impact Provision) Cable Tunnel Geotechnical Baseline Report, Ref: 0032995 (November 2018).

BGS Borehole logs Ground Conditions

10.5.60 The BGS borehole maps identify 38 No. intrusive investigation locations within the Study Area.

10.5.61 Two of the locations are positioned within Area 5 at the location of pylon 4ZC029. While not publicly available through the BGS website, the WSP Desk Study identified these boreholes to show a *"thick sequence of sands and gravels"* it is not apparent if bedrock was encountered but the pylon was installed on 18m pile foundations.

10.5.62 The remaining 36 No. are located broadly along the alignment of the A487 Porthmadog / Minffordd bypass within Area 1, north of the Afon Dwyryd. These are all located to the north of the cable tunnel alignment, at their closest approximately 36m from the alignment. These are part of a wider investigation associated with the construction of the bypass with some following previous alternative routes for the bypass. These are identified by the WSP Desk Study as (NP4 and NT2).

10.5.63 The 36 No. locations within the Study Area are split between trial pits (27 No.) up to 5mbgl and boreholes (9 No.) taken to between 10.3mbgl and 25mbgl. The wider

locations from this series extend north west beyond the Study Area continuing with trial pits and boreholes, the deepest is 50mbgl where a number of deeper boreholes were located adjacent to the Afon Glaslyn, which passes south west through the far north western end of the Study Area.

10.5.64 In review the ground conditions identified by the 36 No. locations broadly comprises topsoil or made ground over alluvial sands and in places granular or cohesive colluvial strata, over bedrock. To summarise the 9 No. boreholes; topsoil is noted in 7 No. of the boreholes between 0.15m and 0.7m thick. The remaining 2 No. boreholes identify made ground from the surface to 3.8mbgl and 6mbgl. All except for the 2 No. boreholes with the highest elevation are underlain by superficial strata. The 2 No. highest locations note bedrock directly below 0.4m and 0.7m of topsoil. Bedrock within the other locations was noted below between 0.35m to 17.5m thickness of superficial strata becoming thinner with elevation at depths between 0.5mbgl and 17.3mbgl.

10.5.65 The underlying bedrock varies significantly in elevation across these locations, being encountered between 28.8mAOD and -15.15mAOD.

WSP Investigations

10.5.66 The reports reviewed to inform the following section are:

- Visual Impact Provision Feed Snowdonia Factual Ground Investigation Report, April 2018, Ref: 70032995.
- Visual Impact Provision: Interpretative Geoenvironmental Report Snowdonia National Park, May 2018, Ref: PDD-33494-REP-013.
- Snowdonia VIP (Visual Impact Provision) Cable Tunnel Geotechnical Baseline Report, Ref: 0032995 (November 2018).

10.5.67 The two phases of ground investigation undertaken as part of the WSP works comprised:

Phase 1

- 28 No. Cone Penetration Test (CPT) locations
- 8 No. Trial Pits.
- 11 No. Cable Percussive Boreholes (8 No. with rotary follow on)
- 8 No. Rotary Boreholes (4 No. cored and 4 No. open hole with cored follow on.

Phase 2

- 4 no. Sonic Boreholes (with rotary follow on) within the estuary to (58 mbgl to 65mbgl).
- 5 no. Rotary Boreholes (40mbgl to 85mbgl).

10.5.68 The intrusive locations are typically focused around the proposed cable alignment, broadening out around the NG Garth Sealing End Compound (SEC) near Minffordd Village.

10.5.69 The ground conditions identified from these intrusive locations are summarised in the WSP Baseline Report. The discussion within the report generally focuses upon the underlying geology specific to the cable tunnel alignment and depth.

10.5.70 The identified geology is in broad alignment with the BGS mapping for the area. The investigation identified superficial strata overlying bedrock within the estuary area and south eastern bank (Areas 2-5). Limited superficial deposits were identified within Area 1

with the majority of the area being thick topsoil over bedrock with the exception of Tidal Flat deposits within the area of the western shaft.

10.5.71 The superficial deposits along the cable tunnel alignment are identified to be relatively horizontal with their boundaries in general conformity with each other. The depth of the superficial strata however varies significantly along the alignment as a reflection of the notable variation in the depth of the underlying bedrock upon which the superficial deposits unconformably lie. This is most evident within the estuary where the bedrock undulates across its width with the deepest locations identified within the southwestern side of the estuary (-58mAOD BH206) which is anticipated to be associated with a fault crossing the area.

10.5.72 The superficial strata are identified by the investigation to comprise a general sequence of Tidal Flat and head deposits over broadly cohesive alluvium, over a variable depth of glacio-fluvial deposits which form the relatively horizontal base to the overlying strata and compensate for the underlying variable bedrock depths. While not discussed within the WSP Report, thin topsoil was noted across the majority of the locations outside of the estuary, with the exception of where peat was identified Peat was also noted overlying the superficial strata within the vicinity of the eastern shaft area (Area 5). baseline report. A brief summary of the strata encountered is presented below:

- Peat: Dark brown pseudo-fibrous Peat within the vicinity of the eastern shaft (Area 5 south of the estuary). These were to a maximum identified depth of 4mbgl but anticipated to be deeper with undulation of the underlying superficial / bedrock strata.
- Tidal flat and head deposits: Present across the western end of alignment and area of the western shaft (Area 1 Minffordd) and across the estuary area from ground level deepening towards the centre of the estuary and thinning out across the south eastern bank as the land raises from the estuary towards the eastern shaft area. The deposits were identified to comprise very loose to lose, fine to medium sand, encountered in places as blowing sands during drilling. The tidal flat and head deposits vary in thickness, between 10m and 12m across the estuary, reducing to below 8m on the southern estuary banks and disappearing further to the east. Superficial deposits are noted within the western shaft area within the WSP Report to extend to their deepest at -20.36mbgl becoming silty with depth (to the west of the western shaft). The Phase 2 investigation identified superficial deposits of sand (including blowing sands) over silts and clays with gravel bands in the immediate vicinity of the western shaft. These deposits around the western shaft are described by the BGS as alluvium. However, the WSP report refers to these as both tidal flat deposits and alluvium. This is likely related to the material's geotechnical classification.
- Alluvium: Underlying the tidal flat deposits within Areas 2-4 and in Area 1 as noted above as well as in places from ground level in Area 5 where the tidal flats thin out. The alluvium comprises soft clay, with greater proportions of silt at depth with lesser amounts of organic matter were also encountered within the alluvium on the eastern side of the estuary. The deepest alluvium was identified in Area 1 close to the western shaft at -20.36mbgl (as discussed above). The alluvium where encountered is commonly soft, dark grey sandy silty Clay/sandy Silt. The WSP report notes the alluvium to vary in thickness with its thickest within the estuary up to 18m thick, thinning out within the west and east banks.
- Glacio/glaciofluvial deposits: the glaciofluvial deposits underlie the alluvium and vary heavily in thickness, following the contours of the underlying bedrock. The strata is generally granular and comprises typically rounded sand, gravel and cobbles. The majority of the glacio/glaciofluvial deposits encountered are described as grey sandy gravel. The deepest and thickest of area of glacio/glaciofluvial deposits is

located within the southern side of the estuary on the southern bank. (borders of Area 3, 4, and 5). In this area the bedrock is identified to be deep, likely due to the faulting in the area and as such the glacio/glaciofluvial deposits are thick. 46.9m thick terminating at bedrock at 58.3mbgl.

10.5.73 The bedrock encountered at the site ranged between 16.7mAOD (atop the high elevations of Area 1) and -55.33mAOD (within the southern bank area of the estuary), at depths of between 0.3mbgl and 58.3mbgl. Typically, bedrock was shallowest within Area 1 where rock outcrops are common and limited topsoil covers the bedrock, and the deepest is typically located within the estuary where the underlying geology is deeper and superficial deposits have built up on the basin.

10.5.74 WSP identify that there is little to differentiate between the three different rock formations identified across the Study Area. The report identifies that only small differences exist between the material properties of the Dol-Cyn-Afon, Ffestiniog Flags, and the Maentwrog Formation, all of which originate from deep ocean, low energy environment deposition. The Dolgellau Formation identified in the BGS mapping was not identified and/ or distinguished during the ground investigation. This may be in part to the lack of borehole locations in the area identified by the BGS or due to the similarity of the materials showing no notable difference in the core samples. The WSP report describes the three main strata as:

- The Dol-Cyn-Afon Formation underlies Area 1 and forms the majority of the bedrock within the Study Area north of the estuary. The bedrock predominantly consists of dark grey to black Mudstone with pyritic mineralisation throughout and “undulating, wavy depositional features”. The boreholes encountered quartz veining particularly within Area 1 around the western shaft (BH101) and in this area the report notes the quartz veining in the A487 road cuttings nearby. The formation typically has a 3m to 5m thick weathered zone represented by oxidation staining and reduced Rock Quality Designation (RQD). Broadly at the boundary of the northern bank (Area 1) and the estuary (Area 2) the Dol-Cyn-Afon Formation gives way to the Ffestiniog Flags Formation.
- The Ffestiniog Flags Formation extends beneath the estuary and into the southern banks, up to the A496 where it is separated from the Maentwrog Formation by the BGS recorded fault on the southern side of the estuary. The Ffestiniog Flags Formation is described as light to dark grey, thinly to thickly laminated, light to dark greenish grey mudstone with laminations described as having “undulating, wavy depositional features” these are less consistent than those within the Dol-Cyn-Afon Formation.
- The Maentwrog Formation is identified within the south eastern boreholes within Area 5. Some surface exposure of the rock is noted in the report and depths are anticipated to be variable. The formation is described as “Interbedded dark and light grey mudstone with pyrite mineralisation”. These are noted to be similar to that of the Ffestiniog Flags Formation but with “significant alteration to the rock mass” in the form of quartz intrusions and deformation at depth likely due to movement along and adjacent to fault zones giving the Maentwrog Formation a generally lower Rock Quality Designation (RQD) and rock strength to that of the Ffestiniog Flags Formation, particularly within areas where the deformation is most significant.

Pyrite

10.5.75 Following the identification of pyrite within the rock formations during ground investigations, WSP produced a technical note on the presence of pyrite within the strata encountered within their investigations and AECOM was commissioned by National Grid to provide a secondary review of the available data, presented as a technical email in January 2019.

10.5.76 Following the reviews, National Grid commissioned testing to further investigate the extent and nature of the pyrite and its relation and potential consequence to the Proposed Project. AECOM investigated with regards to chemical environmental impact, and Stantec with regards to waste. The full findings of the AECOM investigation are provided within the AECOM Pyrite Assessment Report[9].

10.5.77 The findings of the AECOM assessment broadly identified that: *'while the physical appearance of the three formations is similar and in places indistinguishable, the chemical composition with regards to metals and metalloids showed some notable differences'* and noted that the *'Ffestiniog Formation typically recorded the lowest concentrations of [pyrite] indicator chemicals on average in comparison to the other two formations and while the Maentwrog Formation and Dol-cyn Afon Formation were more similar to one another, the Maentwrog Formation typically showed higher concentrations of arsenic, iron and sulphur*'. The analysis identified chemically enriched areas and potentially unaffected areas within each of the strata. The enriched areas were broadly aligned with depth and their proximity to the strata boundaries and/ or fault zones.

10.5.78 With regards to the reuse of arising material within Proposed Project, the AECOM assessment included a review of the materials with regards to human health and controlled waters. The conclusions of the assessment were that it was *'generally not considered that the arisings from the tunnel excavation should pose a risk to human health or controlled waters with regards to metals, metalloids and exotics'*. *'However, consideration should be given to arsenic within the Maentwrog Formation during any additional analysis for reuse of the material with regards to controlled waters'.*

10.5.79 It is not currently known the intended reuse of materials within the scheme. However, should the material be reused, the appointed contractor should incorporate suitable testing, management and mitigation measures to address the points raised within the AECOM report and the potential for pyrite related acid rock drainage (ARD) detailed in an assessment carried out by Stantec[10].

Ground Instability

10.5.80 The BGS GeoSure data within the GroundSure report identifies the following ground instability classifications across the Study Area.

Shrink Swell

10.5.81 Across the Study Area, the shrink-swell hazard rating is in its majority Very Low. Within Area 1 north of the estuary there are two rough bands where the hazard rating is negligible. The bands are oriented north east to south west which broadly follow the two bands of sandstone of the Dol-Cyn-Afon Formation.

Landslides

10.5.82 The landslide mapping of the Study Area identifies a range of hazard level across the area. The most prevalent Hazard rating is Very Low, and makes up the majority of the central portion of the Study Area including most of Areas 2, 3 and 4. Low Hazard bands run through Area 1 north of the estuary and within the north eastern end of Area 2 within the Study area. Within these bands are small areas of Moderate Hazard, notably on the boundary of Area 1 and 2 along the railway. South of the estuary within Area 5, the landslide risk closely follows the topography with Y Garth being classed as a Low Hazard within the Study Area and with a Moderate Hazard following the southern side of

[9] AECOM. 2019. VIP Snowdonia – Pyrite Assessment, Ref: 60603445, 04 September 2019

[10] Stantec 2019. VIP Snowdonia: Tunnel Arisings Acid Rock Drainage Risk Assessment Interpretative Report. Ref: 66721R2. July 2019

Y Garth along the Study Area boundary. Similarly, out of the valley in this area which is a Very Low Hazard, the hills to the east are noted as a Low Hazard with sides into the valley noted as a Moderate Hazard. Within the south western edge of the Study Area is Ynys Gifftan a rock outcrop within the estuary, noted as a Low Hazard with moderate hazards along its edges.

Soluble Rock

10.5.83 According to the GroundSure Report the Study Area outside of the Afon Dwyryd has a Negligible soluble rock hazard rating.

Compressible Ground

10.5.84 The Study Area broadly has a compressible ground hazard rating of Negligible or moderate. Typically, the lower lying areas like that of the estuary, the valley within Area 5 and the north western end of Area 1 have a Hazard rating of Moderate. These are areas where superficial deposits of notable thickness are identified within the ground investigations. Those areas where rockhead is at or near the surface have a negligible rating including the majority of Area 1, the hills within the far east of Area 5, and the Y Garth and Ynys Gifftan outcropping hills. Some small locations in Minffordd in Area 1 are note a Very Low Hazard rating. These are broadly related to strata and the artificial ground areas identified in the GroundSure Report. An area of High Hazard rating extends into the Study Area in Area 1 from the north east along the A487 following a band of peat recorded in the BGS mapping; and the other is a small area located within Minffordd at the existing Garth SEC.

Collapsible Deposits

10.5.85 The mapping of the Collapsible Deposits hazard rating broadly mirrors an inverse of the Compressible hazard map. The majority of the Study Area is identified as having a Negligible Hazard rating typically the lower lying areas like that of the estuary, the valley within Area 5 and the north western end of Area 1. These are areas where superficial deposits of notable thickness are identified within the ground investigations. Those areas where rockhead is at or near the surface have a Very Low Hazard rating such as the majority of Area 1 and Minffordd, the hills within the far east of Area 5, and the Y Garth and Ynys Gifftan outcropping hills.

Running Sands

10.5.86 The GroundSure Report mapping for running sands broadly mirrors that of the mapping for compressible ground. Typically, the lower lying areas, like that of the estuary, the valley within Area 5 have a Hazard rating of Moderate. The majority of the remaining higher ground has a hazard rating of Negligible to very low with the north western portion of Area 1 classified as low hazard. The running sands hazard ratings broadly follow where superficial deposits of notable thickness are identified within the ground investigations. Those areas where rock head is at or near the surface have a negligible rating such as the majority of Area 1 and Minffordd, the hills within the far east of Area 5, and the Y Garth and Ynys Gifftan outcropping hills. Thin bands predominantly within Area 1 and limited in Area 5 note a Very Low hazard rating. These broadly follow artificial ground and noted areas of peat identified in the GroundSure Report, and the other small areas following sandy bedrock strata.

Historic Surface Ground Workings

10.5.87 The GroundSure Report identifies a number of historic surface ground workings as described in Section **Error! Reference source not found.**01 of this appraisal including old quarries, the current quarry, rail cuttings and sewage works. The closest to the Proposed Project, which is no longer present and may present variable fill material, is the former sewage works located adjacent to and overlapping the western tunnel shaft. The report also identified areas of recorded artificial ground, as discussed within the

Published Geology Section. Most are outside of the vicinity of the Proposed Project with the exception of an area of made ground identified at the location of the existing Garth SEC however this is likely related to the construction of the SEC itself.

Radon

10.5.88 The Study Area is located in a radon affected area, as between 3% and 5% of properties are above the action level. Within this action level basic radon protective measures are necessary for new properties or extensions as described within guidance document BRE 211 by the Building Research Establishment.

Hydrogeology

Aquifer Classification and Characteristics

Superficial Deposits:

10.5.89 Alluvium: the alluvial deposits recorded within the north western portion of the Study Area are described by Natural Resources Wales and the BGS as a Secondary (A) Aquifer. The Environment Agency define a Secondary A Aquifer as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

10.5.90 Tidal Flat and Head Deposits: both the limited head deposits recorded in proximity to the A487 within the Study Area, and the tidal flat deposits within the central and the low lying land in the eastern and south eastern portions of the Study Area, have been classified by Natural Resources Wales and the BGS as Secondary Undifferentiated Aquifers. The Environment Agency assign Secondary Undifferentiated Aquifers in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock types.

Bedrock

10.5.91 The bedrock within the Study Area is classified by Natural Resources Wales and the BGS as a Secondary B Aquifer. The Environment Agency describe Secondary B Aquifers as 'mainly lower permeability layers that may store and yield limited amounts of groundwater through characteristics like thin cracks (called fissures) and openings or eroded layers'.

10.5.92 There are no known groundwater abstractions identified by Natural Resources Wales within the Study Area and no active potable water abstractions or groundwater Source Protection Zones (SPZ) lie within the Study Area.

10.5.93 No surface water abstractions are identified within the Study Area however the GroundSure Report identified eight abstractions outside of the Study Area, all of which relate to usage within the Garth Quarry. The consultation with Gwynedd Council identified two private water supplies to the east of the Study Area relating to a spring source for a holiday let and a surface water source for a single dwelling. Both with <10m^3 per day and noted to be monitored continuously. It is not known if these are still in operation the last reviews were November 2018 for the spring and December 2014 for the surface water.

10.5.94 It is likely that the groundwater and surface water levels across the Study Area will be shallow and may locally be tidally influenced.

10.5.95 According to the GroundSure Report, groundwater flooding susceptibility areas lie within the Study Area however no mapping of the areas is available. These are in relation to the potential at surface for Superficial Deposits Flooding (unconsolidated sedimentary aquifers which overlie unproductive strata). This means that given the geological

conditions in the area, the groundwater flooding hazard from unconfined aquifers should be considered.

Vulnerability of Groundwater Resources

10.5.96 According to the GroundSure Report, the soils underlying the Study Area have a High leaching potential (Minor Aquifer). Soils with a High potential and Soil Vulnerability Category classification 'H1' are soils which *'readily transmit liquid discharges because they are shallow or susceptible to rapid flow directly to rock, gravel or groundwater'*.

Hydrology

10.5.97 The majority of the Study Area is a relatively low-lying estuarine environment within or adjacent to the Afon Dwyryd Estuary. The central portion of the Study Area is dominated by the estuary including areas of saltmarsh with narrow drainage channels feeding into the estuary. Away from the estuary the land rises up the valley rises to the north before falling again towards the Afon Glaslyn estuary outside the Study Area.

10.5.98 The valley topography as it rises from the estuary is relatively steep and a number of springs are noted on this hillside outside of the Study Area to the east and to the north east where the topography steepens and where many rock outcrops are recorded.

10.5.99 For a detailed review of the hydrological considerations for the Proposed Project, reference should be made to Chapter 9: Water Resources.

Ground workings

Historic

10.5.100 In addition to the made ground discussed in Section 10.5.37, the GroundSure Report provides a list of Historical Surface Ground Working Features.

10.5.101 The GroundSure Report identified 12 No. locations with multiple entries and a number of single recordings where historical surface ground workings have taken place within the Study Area. The majority of these entries are within Area 1. The main locations include:

- Four locations related to the Garth Quarry;
- Three entries relating to cuttings for the Network Rail railway line: One relating to an elongate rail cutting to the south east of Minffordd; another to a small cutting where the railway passes under the A497 at Minffordd and one north of the former slate quarry yard;
- Two relating to the old quarries noted in the historical review: One quarry in south Minffordd which is now a residential development and the other to the north of the former Bron Y Garth hospital;
- Three relating to infilled ponds: One north east of the former Bron Y Garth hospital; one within the former slate quarry yard [close to the southern boundary of the western infrastructure area] and one adjacent to the Network Rail railway on the boundary of Area 4 and 5 also noted as unspecified ground workings;
- One relating to the cemetery to the west of Minffordd; and
- The three sewage works including the historic filter bed of the sewage works adjacent to the former Explosives Works [at the western tunnel shaft and adjacent to the southern infrastructure area].

10.5.102 Within the Study Area are noted sandpits, unspecified ground workings and heaps, ponds, old quarries and a 'water body'.

Current

10.5.103 The GroundSure Report presents current ground workings, derived from the BGS BRITPITS database (BRITPITS as described by the BGS is an abbreviation of British Pits, and the word 'pits' is used here to include both surface and underground mineral workings) covering active; inactive mines; quarries; oil wells; gas wells and mineral wharves; and rail deposits throughout the British Isles.

10.5.104 Two current ground workings have been identified within the Study Area. Both are described as *'A surface mineral working. It may be termed Quarry, Sand Pit, Clay Pit or Opencast Coal Site*'. However, the report identifies these as 'ceased' and the two entries are related to the former old quarries noted in Section 10.5.101. These are:

- Bryn-derwen – commodity: Slate, located at the old quarry to the south of Minffordd; and
- Hendref Hall – commodity: Sandstone, located to the north of the former Bron Y Garth hospital.

Potentially Contaminative Land Uses

Historic potentially contaminative industrial sites

10.5.105 The GroundSure Report presents a list of 'Potentially Contaminative Uses' of the Study Area. This list presents 158 No. entries for the Study Area. Table 10 presents a list of the different entries. The majority of these entries are captured in more detail within the current land use below and within the historic mapping review (Appendix 10B).

Table 10.5 Summary of historical land uses

Potentially Contaminative Land Uses within the Study Area	
Sewage Works	Railway Buffer Works
Railway Sidings	Filter Bed
Railway Works	Railway Buildings
Disused Railway Works	Sewage Pipe
Railway Station	Hospital
Railway Building	Union Workhouse
Cuttings	Telecomm Exchange
Unspecified Old Quarry	Unspecified Quarry
Cemetery	Unspecified Pit
Railway Land	Quarry (Stone)
Railway Stations	

10.5.106 The GroundSure Report also provides a Historical Tank Database and a Historical Energy Features Database, which are based on the 1:1,250 and 1:2,500 historical mapping. The features identified within the Study Area are summarised in Table 10.6 Note these relate to identifications on the historic mapping 'per sheet' and potentially relate to the same feature over multiple dates [a number of the historic tanks identified are associated with the sewage works at the western tunnel shaft and adjacent to the eastern infrastructure area].

Table 10.6 Summary of historical tanks and energy features

Feature Type	Dates
Historical Tank Database – GroundSure Report	

Feature Type	Dates
Unspecified Tank	1963
Unspecified Tank	1963
Unspecified Tank	1988
Unspecified Tank	1989-1990
Unspecified Tank	1957
Unspecified Tank	1989-1990
Unspecified Tank	1957-1990
Unspecified Tank	1990
Historical Energy Features Database – GroundSure Report	
Electricity Substation	1988-1990
Electricity Substation	1988-1990
Electricity Substation	1990
Electricity Substation	1988-1990
Electricity Substation	1975-1990

Current potentially contaminative industrial sites

10.5.107 The GroundSure Report identifies 42 No. potentially contaminative industrial sites within the Study Area. Sixteen of the 42 No. relate to electricity substations and pylons. Other potentially contaminative industries include:

- Garth Quarry including tanks, conveyors, a chimney, crane and hoppers;
- The Ffestiniog railway and Minffordd and Penrhyndeudraeth railway stations;
- The two sewage works (water treatment facility in Area 5) and associated tanks [one adjacent to the eastern infrastructure area];
- A telephone exchange on the A487 between Minffordd and Penrhyndeudraeth; and
- A depot to the immediate west of the Penrhyndeudraeth railway station.

10.5.108 Gwynedd Council provided a list of potentially contaminated land within the Study Area. This included both current and historical locations when cross referenced to the GroundSure Report. The majority of the entries are for *'unknown filled ground (ponds, marsh, river, stream, doc etc.)'* and are in their majority distributed across Area 1 and Area 2 and relate to those already captured within the GroundSure Report.

Environmental Permits, Pollution Incidents and Registers

Pollution incidents

10.5.109 The GroundSure Report identifies a number of pollution incidents recorded by the National Incidents Recording System (NIRS) within the Study Area:

- No List 1 (i.e. those classified as Category 1 Major Category 2 Significant) incidents have been recorded within the Study Area.
- Six List 2 incidents (i.e. those classified as Category 3 Minor or Category 4 No Impact) were identified within the Study Area.

10.5.110 The six List 2 incidents were reported between 2014 and 2015 with the exception of one in 2002. Of these, only one incident was reported with a water impact, classified as Category 3 (minor) relating to agricultural 'slurry or dilute slurry'. The land impact at four of them were recorded with a Category 3 (minor), and two with a Category 4 (No Impact)

incident. The air impact for the six, noted two with a Category 3 (minor), impact and four with a Category 4 (No Impact) incident.

10.5.111 Based upon the maximum 'minor' impact, any residual contamination as a result of these incidents is not considered to be significant.

10.5.112 The consultation response from Gwynedd Council noted no major pollution incidents within the Study Area.

Permits and registers

10.5.113 The GroundSure Report identified 12 No. discharge consents within the Study Area. These typically relate to trade discharges and storm water or tank overflows as well as treated effluent. The majority of the discharge consents within the Study Area are on the eastern boundary within Area 2 adjacent to the Network Rail railway and within the eastern sewage works, the water treatment facility and the Garth Quarry. One Integrated Pollution Control (IPC) Authorisation was noted 188m north of the Study Area relating to Nobel's Explosives Co. Ltd. at the Cooks Works Explosives Works for acid processes.

10.5.114 One entry was noted within the Study Area for a List 2 Dangerous Substance Inventory Site named Cilfor Wtw Cilfor for the water treatment works in Area 5, noted as active with authorisation for 'Iron and pH'.

10.5.115 With regards to environmental permits no regulated Part A1 records are included in the GroundSure Report for the Study Area. However, three records for Part A(2) and Part B Activities and Enforcements were recorded within the Study Area. (Part A2 and B are Local Authority regulated, and comparatively less polluting, Part A2 activities are for multi-media emissions and the lesser polluting Part B activities are for emissions to air only). Two of the entries relate to the Slate Quarry Yard in Minffordd for the use of bulk cement one of which is noted as currently active. The remaining entry is active, for quarry and coating processes, and relates to Tarmac Lafarge Ltd at Garth Quarry.

10.5.116 The correspondence from Gwynedd Council identified three Part B permits for Part B activities and broadly relate to those activities noted in the GroundSure Report: two related to the Minffordd (Garth) Quarry for roadstone coating and cement batching (rated low), and quarry processes (rated medium).

Landfill and waste permits

10.5.117 One historic landfill has been identified within the Study Area on lower road, Minffordd taking household waste and likely to be associated with the wider area of artificial ground noted in this area in Section 10.5.37. This was operated by Deudraeth Rural District Council and was first registered in 1947 with the licence expiring in 1982. The consultation with Gwynedd Council names this site 'Minffordd Lower Road Landfill Site'.

10.5.118 One BGS / Department of Environment (DoE) non-operational landfill site was recorded which related to Minffordd Lower Road Landfill Site' but is noted 39m north of the Study Area.

10.5.119 One operational landfill site has been identified within the Study Area, north west of the former Bron Y Garth Hospital. This is noted as a being a 'Refuse Tip' but no other information is provided.

10.5.120 One waste treatment, transfer or disposal site was identified within the Study Area, located to the east of the Snowdonia National Trust office. This is for a site noted as a vehicle recycling facility relating to a 'change of use of a demolition contractors depot for the use of land as a metal recovery, vehicle recycling facility, storage of scrap metal and siting of weighbridge'. During the walkover no notable facility was identified. The location is near a set of garages within a housing estate and a large corrugated shed is noted in the back.

10.5.121 Seven entries are recorded for waste treatment, transfer or disposal sites within the Study Area however these relate to only two locations both within Garth Quarry relating to 'Management of inert or extractive waste at mine' for Garth Quarry and Tarmac Trading Ltd.

10.5.122 The GroundSure Report covers a number of additional records to those discussed above. The following records have been reviewed and showed no records for the Study Area:

- Historical Petrol and Fuel Sites;
- Historical Garage and Motor Vehicle Repair Database;
- Historical Military Sites;
- Environment Agency/Natural Resources Wales Registered Landfill Sites;
- Sites Determined as Contaminated Land under Part 2A EPA 1990;
- COMAH & NIHHS sites;
- Red List Discharge Consents (potentially harmful discharges to controlled waters);
- Water Industry Referrals (potentially harmful discharges to the public sewer);
- Planning Hazardous Substance Consents and Enforcements;
- List 1 or List 2 Dangerous Substances Inventory Sites;
- Part A(2) and Part B Activities and Enforcements;
- Radioactive Substances Authorisations;
- Waste Industry Referrals; and
- Planning Hazardous Substance Consents and Enforcements.

Mineral Sites

10.5.123 BGS safeguarding maps for Wales including the 'Mineral Resources Map of Wales' series and 'Aggregates Safeguarding Map of Wales' series identify the Garth (Minffordd) Quarry and the Peat deposits in the Study Area.

10.5.124 The BGS GeoIndex indicates mineral resources within the Study Area including a band of igneous rock (Dolerite) running from the north west into the Study Area at the location of the Garth Quarry. This band follows a sandstone band outside of the Study Area. The majority of the Study Area is also noted as a potential *'slate resource with recorded workings'*, and the Peat noted in the Study Area is also identified as a potential resource.

10.5.125 The mapping and BGS' GeoIndex records note the Garth Quarry as an active site for 'igneous/metamorphic extraction' and identify the site as producing 'roadstone and railway ballast'.

10.5.126 No coal seams or related works or coal mining were recorded by the Coal Authority and GroundSure Report within the vicinity of the Study Area.

10.5.127 The GroundSure Report identifies five non-coal mining locations within the Study Area relating to vein minerals and noted as '*Localised small scale underground mining may have occurred. Potential for difficult ground conditions are unlikely or localised and are at a level where they need not be considered'*. These appear to be located on the boundaries of the Study Area.

10.5.128 The GroundSure Report identifies no tin, gypsum or clay mining and no brine extraction or natural cavities within the Study Area.

10.5.129 Outside of the Study Area there are a number of mineral occurrences shown to the east and south which, in a number of locations, have associated metal mines.

Statutory and Non-Designated Sites

10.5.130 Statutory and non-statutory designated sites for nature conservation are shown on Figure 7.1 and are discussed in Chapter 7: Ecology.

10.5.131 The southern section of the site, including Area 5 and sections of Areas 3 and 4, are contained within the boundary of the Snowdonia National Park. [includes the eastern infrastructure area and the eastern portion of the pylon removal areas].

10.5.132 Small pockets of Ancient Woodland are noted within Area 1 to the south and east of Minffordd. While not crossing the Site Boundary [close to the western pylon removal areas].

10.5.133 Two SSSI are recorded within the Study Area and a third borders the Study Area:

- **Ysbyty Bron Y Garth:** The SSSI is located north of Minffordd and extends into the Study Area. [this area covers the western end of the pylon removal areas and the eastern section of the western infrastructure area]
- **Morfa Harlech:** A very large SSSI site covering the majority of the Afon Dwyryd in this area, and the surrounding estuary tidal flats. Morfa Harlech covers the bulk of the central and eastern portion of the Study Area. Morfa Harlech is also identified as a National Nature Reserve (NNR). [this area overlaps the pylon removal areas within the centre east of the alignment of the Proposed Project]
- **Glaslyn:** The SSSI is located to the immediate north west of the Study Area. The Morfa Harlech SSSI site is also designated as a Special Area of Conservation (SAC). [the area lies west of and adjacent to the western infrastructure area].

10.5.134 Special Areas of Conservation (SAC) are identified on-site including Pen Llyn a'r Sarnau (Lleyn Peninsula and the Sarnau) and Coedydd Derw a Safleoedd Ystlumod Meirion (Meirionnydd Oakwoods and Bat Sites). Within the Study Area, the Pen Llyn a'r Sarnau SAC corresponds with the area of the Morfa Harlech SSSI, including the Dwyryd Estuary and tidal flats (Areas 2, 3 and 4). The Coedydd Derw a Safleoedd Ystlumod Meirion SAC covers the area to the south west of Garth Quarry along the Afon Glaslyn but extend into the area of temporary works close to the western tunnel shaft location. These areas are considered in detail within Chapter 6: Landscape and Visual and Chapter 7: Ecology.

Unexploded Ordnance

10.5.135 A review of the publicly available Unexploded Ordnance (UXO) risk maps provided by Zetica has been made for the Study Area. These maps identify the potential for UXO to be present as a result of WWII bombing and provide a high-level assessment of regional WWII bombing density in the UK.

10.5.136 The mapping indicates that within the Study Area the unexploded bomb risk is negligible (a below 'low' risk identified on the mapping). In addition, the mapping identifies no points of note or strategic targets within the Study Area with regards to military activity. The closest strategic targets are noted to be 'utilities' at the Ceunant Geifr, (a valley) and Maentwrog Dam classified as a Luftwaffe target, both over 3km east of the Study Area.

10.5.137 However, as identified through the GroundSure Report, an Explosives Works was present on the north eastern boundary of the Study Area to the east of Penrhyndeudraeth. The works opened as Cookes Explosives in 1872 and later became part of the Imperial Chemical Industries (I.C.I). The works made 'guncotton' (Nitrocellulose) for military, mining and quarrying use. The works expanded significantly

to supply increased demand during World War I, but following the reduction in mining in the UK, the works closed in 1995. The works were cleared by 1997 and the site is now home to a nature reserve. Although it is not understood whether explosive ordnance was present within the works and while the potential for the presence of explosive material remaining at the site is limited, it is possible that the site may have been a military target extending into World War II.

10.6 Conceptual Site Model and Preliminary Risk Assessment – Contamination

10.6.1 This section presents a Conceptual Site Model (CSM) which has been developed based on the information presented above. The CSM identifies the potential sources of contaminants and receptors and presents a discussion of the associated plausible pollutant linkages; i.e. a mechanism whereby a source may impact on a sensitive receptor via a pathway. Both past and current potentially contaminative land uses have been considered.

10.6.2 A risk assessment of the identified plausible pollution linkages has been undertaken for the site in line with current legislation. The assessment takes into consideration the sources of possible contamination risk and the presence of plausible pathways and receptors. It provides the initial phase of the process of managing land contamination detailed in the Environment Agency CLR11 guidance.

10.6.3 Using criteria broadly based on those presented in Section 6.3 of the CIRIA Report C552[11] the magnitude of the risk associated with potential contamination at the site has been assessed. An explanation of the terms used in this risk assessment is given in Tables 10.7 to 10.9.

Table 10.7: Severity of risk

Severity	Examples
High	Acute risks to human health likely to result in "significant harm" (e.g. very high concentrations of contaminants/ground gases). Catastrophic damage to buildings/property (e.g. by explosion, sites with high gassing potential, extensive VOC contamination). Major pollution of controlled waters (e.g. surface watercourses or principal aquifers/source protection zones) Short term risk to a particular ecosystem.
Medium	Chronic (long-term) risk to human health likely to result in "significant harm" (e.g. elevated concentration of contaminants/ground gases). Pollution of sensitive controlled waters (e.g. surface watercourses or principal/secondary A aquifers). Significant effects on sensitive ecosystems or species.
Mild	Pollution of non-sensitive waters (e.g. smaller surface watercourses or secondary B aquifers or unproductive strata). Significant damage to crops, buildings, structures or services (e.g. by explosion, sites with medium gassing potential, elevated concentrations of contaminants).

[11] Rudland et al. (2001). Contaminated Land Risk Assessment: A Guide to Good Practice. CIRIA Report C552. CIRIA. London

Severity	Examples
Minor	Non-permanent human health effects (requirement for protective equipment during site works to mitigate health effects). Damage to non-sensitive ecosystems or species. Minor (easily repairable) damage to buildings, structures or services (e.g. by explosion, sites with low gassing potential).

Table 10.8: Probability of risk occurrence

Likelihood	Description
High	Pollutant linkage may be present that appears very likely in the short-term and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
Low	Pollutant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur even in the long-term are improbable.

Table 10-9 Risk based on comparison of likelihood and severity

		Severity			
		High	Medium	Mild	Minor
Likelihood	High	Very High	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very low	Very low

10.6.4 With reference to the review of Proposed Project above, the following potential sources of contamination which may be anticipated within the Site Boundary are noted in

10.6.5 Table 10.10 The potential contaminants included are based upon typical contaminants listed in the DoE industry profiles, associated with activities noted within and in close proximity to the Site Boundary.

Table 10.10: Potential Sources and Contaminants of Concern

Source	Location / Activity	Potential Contaminants of Concern
S1 – Potentially contaminated Made ground and fill material.	Areas of infilled land and potentially infilled land were identified within the Study Area. Those within the Site Boundary include artificial land at Maenofferen Slate Quarry yard and the existing Garth SEC. Historic workings likely to comprise made ground include the three rail cuttings, a cemetery (Area 1) and land associated with the sewage works and water treatment works in Areas 1 and 5.	Unknown constituents of Made Ground (Potentially including: metals, metalloids and inorganics, phenols, sulphates, asbestos, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPH)). Landfill gas generation (carbon dioxide, methane).
S2 – Current land uses	The main current potentially contaminative land uses in the Site Boundary include: - Electricity transmission infrastructure including pylons and substations - Sewage works - Water treatment works (adjacent to the proposed south SEC and temporary works). - The towns of Minffordd and Penrhyndeudraeth. - Roads, railways and associated infrastructure including depots. - Cemetery in western end of Area 1.	Contaminants may include: metals, metalloids and inorganics, phenols, sulphates, asbestos, PAH and TPH. Potential contaminants from DoE Profiles: - Sewage works / water treatment works – metals, inorganics, organics, solvents, pesticides, biodegradable material, asbestos and treatment chemicals. (gas generation: carbon dioxide, methane, trace carbon monoxide and hydrogen sulphide). - Railway Land – TPH, PAH, solvents, sulphates, polychlorinated biphenyls (PCB), herbicides, metals, asbestos, ash and fill - Pylons and substations – PCB, metals, solvents, lubricating oils, mineral oils, asbestos.
S3 – Historical land uses	Historical land uses in the Site Boundary include: - Sewage works facilities including tanks and filter beds and the former sewage works (at the western tunnel shaft and SEC permanent and temporary works). - Former hospital and work house. - Depot and railway works.	Contaminants may include: metals, metalloids and inorganics, phenols, sulphates, asbestos, PAH TPH. Potential contaminants from DoE Profiles: - Sewage works – metals, inorganics, organics, solvents, pesticides, biodegradable material, asbestos and treatment chemicals. (gas generation: carbon dioxide, methane, trace carbon monoxide and hydrogen sulphide). - Railway Land – TPH, PAH, solvents, sulphates, PCB,

Source	Location / Activity	Potential Contaminants of Concern
		herbicides, metals, asbestos, ash and fill - Pylons and substations – PCB, metals, solvents, lubricating oils, mineral oils, asbestos.
S4 – Chemically aggressive soils	Current and historic land use may present potentially chemically aggressive soils.	Elevated sulphate and sulphide and / or low pH conditions within site soil and or groundwater.
S5 – Buried cement of the proposed development	The Proposed Project includes the installation of below ground structures and foundations utilising cement-based products.	Concrete, pH
S6 – Construction activities	The construction of the Proposed Project will require various plant, vehicles and construction materials across the Study Area.	Contaminants may include: fuels and oils, metals, concrete, pH.
S7 – Construction arisings	The Proposed Project will produce a quantity of arisings from the underground works.	Pyrite presence within bedrock has the potential for Acid Rock Drainage (ARD) and the Maentwrog Formation has been identified as being a potential source of elevated arsenic.

10.6.6 Potential contaminative features which are within the Study Area but not carried through the assessment are listed below. The reason for the particular feature not being considered further may be due to it not being within a sufficiently close proximity of the Site Boundary and as such are not likely to be disturbed by, or effect the Proposed Project, or the risk posed by the feature is considered to be insignificant.

- Breedon Minffordd (Garth) Quarry and Breedon Minffordd Quarry Yard;
- Lower Road Minffordd landfill;
- The two former quarries, later historical landfills;
- The sewage treatment works in Area 2;
- Cooks Works Explosive Works now Gwynedd Environmental Waste Services Ltd;
- Maenofferen Slate Quarry yard in Minffordd;
- Small features including sandpits and unspecified quarries, pits and infilled ponds;
- UXO (The Zetica mapping indicates a negligible risk); and
- Historical pollution incidents.

10.6.7 The principal contamination pathways may include the following:

- P1 – Dermal contact, inhalation or ingestion of contaminants present in topsoil, Made Ground or underlying strata, during works and post-development;
- P2 – Inhalation and / or accumulation of ground gas / organic vapours;
- P3 – Leaching of contaminants, impacting on and migrating in groundwater;
- P4 – Surface water run-off and / or direct percolation from surface;
- P5 – Direct contact of Made or Natural Ground with in-ground structures;
- P6 – Plant / animal uptake of the contaminants present in Made Ground, topsoil, underlying strata or surface water features; and,
- P7 – Wind-blown migration of contaminated dust.

10.6.8 The principal receptors for contamination may include the following:

- *Human Health Receptors*

  R1 – Final end users (trespassers, public, visitors, staff and maintenance workers);

  R2 – Construction workers; and

  R3 – Adjacent site users (residents of residential properties and local workers).

- *Controlled Waters Receptors*

  R4 – Groundwater:

  - Superficial Deposits: Secondary A Aquifers and Secondary Undifferentiated Aquifers (Alluvium, and tidal flat and head deposits respectively);
  - Bedrock: Secondary Undifferentiated Aquifer (Mawddach Group);
  - Anticipated shallow potentially tidally influenced groundwater;
  - No potable waters or SPZ were identified within the vicinity of the Study Area.

  R5 – Surface Water:

  - The Afon Dwyryd and associated estuary and saltmarshes.
  - Streams and rivers leading to the Afon Dwyryd estuary.

- Streams within the Study Area leading to the Afon Glaslyn to the north west of the Study Area.

- *Ecological Receptors*

  R6 – Sensitive Land Uses – The SACs Lleyn Peninsula and the Sarnau; and Meirionnydd Oakwoods and Bat Site, SSSI's Ysbyty Bron Y Garth, Morfa Harlech and Glaslyn, the south eastern section of the Study Area within the Snowdonia National Park and the small pockets of Ancient Woodland.

  R7 – Groundwater and surface water fed streams and estuary.

- *Property Receptors*

  R8 – New underground cable route and SECs and associated infrastructure including temporary construction compounds.

  R9 – Adjacent (adjacent to the Site Boundary) residential and commercial properties.

- *Resource Receptors*

  R10 – Mineral resources;

  - Mawddach Group – The majority of the Study Area as a potential slate resource with recorded workings.
  - Garth Quarry - an active site for igneous/metamorphic extraction of Dolerite

  R11 – Peat deposits identified within Area 1 where peat may be over 1m thick.

10.6.9 A Conceptual Site Model (CSM) describing plausible pollutant linkages has been formulated for the site and a discussion of the plausible pollutant linkages of the sources, pathways and receptors is provided in Table 10-11.

Table 10.11: Plausible Pollutant Linkages and Qualitative Risk Assessment

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
Hazards to Human Health						
S1 – Made ground / fill material S2 – Current land uses S3 – Historical land uses	P1 – Dermal contact, inhalation or ingestion of the contaminants present in topsoil or underlying strata, during works and post-development. P7 – Wind-blown migration of contaminated dust	R1 – Final end users	Mild	Unlikely	Very low	Potential sources of contamination were identified in the Site Boundary, however, the presence and composition of fill and made ground across the majority of the route is currently unknown. It is however noted that the majority of the above ground sections of the Proposed Project are within broadly undeveloped land and have been fields since at least 1886, with the exception of the existing Garth SEC which is partially located within the position of a former sewage works. Once complete, the above ground footprint of the Proposed Project shall be limited. Apart from the pylons which are broadly open to the public, the SEC and tunnel head houses are anticipated to be closed off to the public and as such access to these areas shall be limited to trespassers, authorised personnel and visitors. It is anticipated that the Proposed Project shall include the removal of geotechnically unsuitable made ground during construction and that the majority of the facilities shall comprise hard standing and limited to negligible contact of end users with soils.

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
		R2 – Construction	Mild	Low	Low	Potential sources of contamination were identified in the Site Boundary. Complete contaminant linkages are considered to be present but short term i.e. for the duration of earthworks exposing contaminated ground. These would be managed by the implementation of appropriate risk assessment and mitigation measures during construction.
		R3 – Adjacent site users.	Mild	Unlikely	Very low	Potential sources of contamination were identified in the Site Boundary. These linkages are considered to relate to the short term during construction i.e. for the duration of earthworks exposing contaminated ground. These would be managed by the implementation of appropriate risk assessment and mitigation measures during construction.
S1 – Made ground / fill material	P2 – Inhalation and / or accumulation of ground gas / organic vapours.	R1 – Final end users.	Medium	Low	Moderate / low	Made Ground and infilled land has been recorded or anticipated in the Site Boundary notably within the vicinity of the Western tunnel shaft. While a number of landfills are located within the Study Area they are not within the vicinity of the Proposed Project. However, within the vicinity of the Western tunnel shaft a former sewage works was noted and there is the potential for notable made ground to be present within this area. It is possible that should the made ground be present at the former sewage works and should this generate ground gas there is the potential for migration to the confined

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
						spaces of the shaft and associated structures. Should adverse gas conditions be present final end users (site workers) may suffer chronic exposure over time dependent upon works and consideration should be given to the final end user exposure to gas accumulated in enclosed spaces and suitable mitigation measures implemented.
		R2 – Construction workers.	Mild	Likely	Moderate / low	Made ground and infilled land has been recorded or anticipated in the Site Boundary notably within the vicinity of the western tunnel shaft. While the Proposed Project is typically at distance from the noted landfills within the Study Area, the western tunnel shaft is located on or adjacent to a former sewage works. With the exception of potentially gas generating buried made ground adjacent to the western tunnel shaft, the landfills noted in the Study Area are typically in areas of limited superficial strata, and uphill from the Proposed Project negating the potential for a viable contaminant linkage.
		R3 – Adjacent site users.	Mild	Unlikely	Very low	Made ground and infilled land has been recorded or anticipated in the Site Boundary notably within the vicinity of the Western tunnel shaft. The Proposed Project is typically at distance from the noted landfills within the Study Area, however the western tunnel shaft is

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
						located on or adjacent to a former sewage works. With the exception of potentially gas generating buried made ground adjacent to the western tunnel shaft, the landfills noted in the Study Area are typically in areas of limited superficial strata, and up topographic gradient from the Proposed Project negating the potential for a connecting PPL. Should ground gas generating fill material be located at the former sewage works, then a viable contaminant linkage may be present.
Hazards to the Water Environment						
Garth SEC: S1 – Made ground / fill material S2 – Current land uses S4 – Historical land uses	P3 – Leaching of contaminants, impacting on and migrating in groundwater.	R4 – Surface waters R5 – Groundwater	Medium	Likely	Moderate	Made ground and infilled land has been recorded or anticipated in the Site Boundary the composition of which is unknown. While landfills are noted within the Study Area these are not located close to the Proposed Project. The nearest potential sources of leachate to the area are the former sewage works and Slate Quarry Yard. These have the potential for generation and migration of contaminative leachate. Within Area 1 the superficial geology is typically thin or not present, with outcropping bedrock across the area and groundwater is anticipated to be relatively shallow and likely to flow south towards the Afon Dwyryd or north west towards the Afon Glaslyn with the potential to be tidally influenced, related to the estuaries.

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
Eastern SEC: S1 – Made ground / fill material S2 – Current land uses S3 – Historical land uses	P3 – Leaching of contaminants, impacting on and migrating in groundwater.	R4 – Surface waters R5 – Groundwater	Medium	Likely	Moderate	Made ground and infilled land has been recorded or anticipated in the Site Boundary the composition of which is unknown. While landfills are noted within the Study Area these are not located close to the Proposed Project or Eastern SEC area. The nearest potential sources of leachate to the area is the current water treatment works (Water Treatment Facility), adjacent to the Site Boundary, which has the potential for generation and migration of contaminative leachate from made ground. Within Area 5 the superficial geology is thicker than that on Area 1 comprising tidal flat deposits over cohesive superficial deposits of soft clay and silt, however the area is still dominated by outcropping bedrock and springs are noted outside the Study Area uphill from the Eastern SEC area. Groundwater is anticipated to be shallow and likely to flow north east towards the Afon Dwyryd broadly following the topography along the valley. The deeper groundwater may have the potential to be tidally influenced in this area related to the estuaries.
Site Wide: S5 – The buried concrete of the proposed	P3 – Leaching of contaminants, impacting on and migrating in groundwater.	R4 – Surface waters R5 – Groundwater	Medium	Unlikely	Low	The potential for the buried concrete of the proposed development to leach contaminants or increase the alkalinity of the site groundwater may be present. In addition, the majority of the concrete to be utilised within the project shall be pre-

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
development S6 – Construction activities S7 – Construction arisings						cast which should be less susceptible to generating alkaline leachate.
Garth SEC: S1 – Made ground / fill material S2 – Current land uses S3 – Historical land uses	P4 – Surface water run-off and / or direct percolation from surface.	R4 – Surface waters R5 – Groundwater	Medium	Low	Moderate / low	Made ground and infilled land has been recorded or anticipated in the Site Boundary, the composition of which is unknown. Apart from an electrical substation and the existing SEC, no notable sources of contamination are present at the surface. While landfills are noted within the Study Area these are not located close to the Proposed Project. The nearest potential sources of leachates to the area are the former sewage works at the location of the western tunnel shaft which includes infilled land. While the area around the Garth SEC is predominantly fields, with some water logging and a small stream running through, there are no notable sources of contamination, with the exception of potentially some input from the infilled land of the former sewage works which lies slightly up hill from the water-logged fields.
Eastern SEC: S1 – Made ground / fill material	P4 – Surface water run-off and / or direct percolation from surface.	R4 – Surface waters R5 –	Medium	Unlikely	Low	Made ground and infilled land has been recorded or anticipated in the Site Boundary, the composition of which is unknown. Apart from the existing Water

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
S2 – Current land uses S3 – Historical land uses		Groundwater				Treatment Facility, no notable sources of contamination are present at the surface or up gradient of the Eastern SEC. While landfills are noted within the Study Area these are not located close to the Proposed Project or Eastern SEC area. While the area around the Eastern SEC is predominantly fields with rough grasses and gorse, some water logging and a small stream running along the valley is present, cutting through to the south west and the estuary. There are no notable sources of contamination with the exception of potentially some input from current water treatment works and pylons, which lie slightly up hill from the fields.
Site Wide: S5 – The buried concrete of the proposed development S6 – Construction activities	P4 – Surface water run-off and / or direct percolation from surface.	R4 – Surface waters R5 – Groundwater	Medium	Low	Moderate / low	The majority of the concrete to be utilised within the project shall be pre-cast reducing the potential for leaching. However, some sprayed concrete is anticipated for which the high pH may present the potential to mobilise arsenic within the bedrock.
Hazards to Ecological Receptors						
Garth SEC: S1 – Made ground / fill material S2 – Current land uses S3 – Historical	P6 – Plant / animal uptake of the contaminants present in made ground, topsoil, underlying strata or surface water	R6 – Sensitive Land uses R7 – Groundwater and surface	Minor	Unlikely	Very low	Made ground and infilled land has been recorded or anticipated in the Site Boundary, the composition of which is unknown. Apart from an electrical substation and the existing SEC, no notable sources of contamination are present at the surface. While landfills are

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
land uses	features.	water fed streams and estuary				noted within the Study Area these are not located close to the Proposed Project. The nearest potential sources of potential contamination in the area are the former sewage works which includes infilled land. The SSSI of the Ysbyty Bron Y Garth lies in sections to the immediate north east through to south east of the existing Garth SEC. However, the main area of the SEC and tunnel shaft are not within an environmentally sensitive area.
Eastern SEC: S1 – Made ground / fill material S2 – Current land uses S4 – Historical land uses	P6 – Plant / animal uptake of the contaminants present in made ground, topsoil, underlying strata or surface water features.	R6 – Sensitive Land uses R7 – Groundwater and surface water fed streams and estuary	Minor	Unlikely	Very low	Made ground and infilled land has been recorded or is anticipated in the Site Boundary, the composition of which is currently unknown. Apart from the existing water treatment works (Water Treatment Facility), no notable sources of contamination are present at the surface or up gradient of the Eastern SEC. While landfills are noted within the Study Area these are not located close to the Proposed Project or Eastern SEC area. The Eastern SEC area is within the Snowdonia National Park and is located to the east of the Morfa Harlech SSSI and Lleyn Peninsula and the Sarnau SAC. However, the potential sources of contamination are considered limited.
Hazards to Building Fabric, Structures and Services						

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
S1 – Made ground / fill material S2 – Current land uses S3 – Historical land uses S4 – Chemically aggressive soils	P5 – Direct contact of made or natural ground with in-ground structures.	R9 – New underground cable route and SECs.	Mild	Low	Low	Potential sources of made ground and infilled land are recorded / anticipated in the Site Boundary. Where there is the potential for made ground within the location of the Proposed Project there is the potential for aggressive soils with regards to concrete and underground structures. There is also the potential for the presence of low pH levels and elevated sulphates / sulphides within natural soils.
S1 – Made ground / fill material	P2 – Accumulation of ground gas / organic vapours.	R8 – SECs and temporary construction compounds. R9 – Adjacent residential properties and listed buildings.	Medium	Low	Moderate / low	Made ground and infilled land has been recorded or anticipated in the Site Boundary, notably within the vicinity of the Western tunnel shaft. The Proposed Project is typically at distance from the noted landfills within the Study Area, however the western tunnel shaft is located on or adjacent to a former sewage works. With the exception of potentially gas-generating buried made ground adjacent to the western tunnel shaft, the landfills noted in the Study Area are typically in areas of limited superficial strata, and uphill from the Proposed Project negating the potential for a connecting PPL. Should ground gas-generating fill material be located at the former sewage works, or within the vicinity of the receptors, then a PPL may be present. The potential for the accumulation of ground gas / organic vapours posing a risk to buildings e.g. through explosive atmospheres may be

Source(s)	Pathway	Receptor(s)	Consequence (Severity)	Probability (Likelihood)	Risk	Description of Plausible Pollutant Linkage
						present but is considered limited. In addition, with regards to R9 – Adjacent residential properties and listed buildings, apart from the disturbance of potential made ground during construction, the PPL shall have been present prior to the Proposed Project.
Hazards to Resource Receptors						
S1 – Made Ground / fill material S2 – Current land uses S3 – Historical land uses	P3 – Leaching of contaminants, impacting on and migrating in groundwater. P4 – Surface water run-off and / or direct percolation from surface.	R10 – Mineral resources R11 – Peat deposits	Minor	Low	Very low	While the PPL for contamination of the mineral resources and peat deposits underlying the site and at ground level is present, any potential release of contaminants during construction would be localised and temporary.

10.7 Conceptual Site Model – Hydrogeology

10.7.1 This section describes the hydrogeological characteristics and aquifer units in relation to those sensitive receptors which may be influenced i.e. the SACs, SSSIs, NNR, and ancient woodland in the south eastern section of the Study Area within the Snowdonia National Park. A source-pathway-receptor methodology has been used to model the Study Area and allow assessment of the potential impact of the Proposed Project on the site's hydrogeological system.

Source

10.7.2 The Study Area lies broadly across the Afon Dwyryd estuary which lies within a geological syncline oriented north eat to south west. Topographically the site broadly dips down into the saltmarshes of the estuary. A network of rivers run across the land-side Areas 1 and 5 towards the estuary and the saltflats are dissected by tidal drainage channels cutting the flat land into a sequence of islands. Within the northern end of the Study Area the existing Garth SEC lies on the boundary of the catchment for the Afon Dwyryd and the Afon Glaslyn to the north west and it is possible the streams and ditches in these areas may feed either river. The rivers themselves lie in wide sand and silt with the base of the land-side Area 1 and Area 5 being above the tidal limit. As such the groundwater within the area of the rivers has the potential to be tidally influenced. Bedrock is generally shallow and within elevated areas of the Study Area, such as those up the valley to the north and south of Area 5, springs are noted on the historic mapping leading downgradient to the estuary.

10.7.3 As such the source of water in the hydrogeological system of the Study Area is likely split between rainfall recharge of the higher ground, through typically granular limited superficial strata to the underlying Secondary Undifferentiated Aquifer; and a tidal influence on the groundwater in the lower-lying coastal margin. Groundwater within the strata close to the coastal margin, and beneath the river estuary, is likely to be tidally influenced and may be brackish or saline. Any saline intrusion into the aquifer units is likely to reduce the water quality and groundwater resource potential.

10.7.4 Further detail on the hydrological setting of the Study Area is given in Chapter 9: Water Resources of this Environmental Appraisal.

Pathway and Receptors

10.7.5 As described previously, the topography of the Study Area is broadly basin-like and as such rainwater that falls on the higher ground to the north and south ends of the Study Area likely either infiltrates through the granular superficial strata to the top of the bedrock (Secondary Undifferentiated Aquifer) or forms small surface water features (rivers and streams, or follows drainage channels), particularly where lower permeability silt and clay deposits are present. These surface water features are likely ephemeral and potentially not present in the summer months or periods of low rainfall. In general, these streams flow towards the Afon Dwyryd estuary and saltmarshes at the base of the main valley with the exception of those running north from Area 1, which are within the Afon Glaslyn catchment. Within some sections of Area 1 and Area 5, water ponds within marshy conditions. The collecting and ponding of the rainfall creates ecological habitats and provides a water source for grazing livestock.

10.7.6 The identified surface water and groundwater flow pathways include:

- Surface water flow within excavated and natural drainage channels through Area 1 and Area 5;
- Vertical infiltration of rainfall into the granular superficial deposits and shallow bedrock;

- Lateral migration of groundwater feeding springs / spring lines and providing baseflow to streams; and
- Discharge of groundwater to the Afon Dwyryd and Afon Glaslyn estuaries, supporting surface water flow.

10.7.7 The principal hydrological and hydrogeological receptors identified include:

- Shallow or perched groundwater aquifers within the granular superficial strata over more cohesive superficial strata;
- The bedrock groundwater aquifer;
- Surface water flows overland to the saltmarshes and estuaries; and
- SACs, SSSI locations, NNR and the National Park.

Potential Effects on Hydrogeology from Proposed Project

10.7.8 The Proposed Project has the potential to disrupt the hydrogeological pathways of the site and therefore potentially impact the groundwater, surface water and ecological receptors. Pathway disruption could result from the following:

10.7.9 The construction of the tunnel and the tunnel shafts will require the dewatering of the excavations and the pumped water will be discharged following any required treatment. This removal and/or interference with the shallow groundwater may potentially create a drawdown effect within the groundwater with the potential to impact the volume and flow rate of surface water streams and saltmarsh and the associated sensitive ecological receptors.

10.7.10 However, in the case of the eastern tunnel shaft, the final depth will be between 39.5 and 73.5m deep and therefore the pumping of any near-surface groundwater ingress would occur only during the initial drilling of the shaft. As the construction of the shaft progresses, pumping of any groundwater ingress would occur at progressively lower depths, until the ultimate construction depth of the shaft is reached. At this depth, and given the anticipated volume and rate of pumping, it is unlikely that the transmissivity of the geology above the ultimate tunnel and shaft base elevation would be sufficient to allow a drawdown effect that could impact surface water features and any impact would inherently be temporary.

10.7.11 Additional hard standing cover shall be placed within the Study Area as part of the development of the permanent and temporary access, the tunnel head houses and the eastern SEC and associated infrastructure. While this additional hard standing may impact surface infiltration of waters locally, it is not considered that it should present a notable impact to the groundwater regime of the Study Area as a whole.

10.8 Key Parameters for Assessment (Embedded Mitigation)

10.8.1 Relevant mitigation measures that have been adopted as part of the evolution of the project design (embedded into the project design) and that are relevant to this Chapter are listed below.

10.8.2 During Construction / reinstatement the following embedded mitigation is considered relevant:

- A CEMP will be prepared and used to manage environmental impacts to air, land and water from construction operations. This will include a commitment to follow appropriate industry best practice and published guidelines to reduce pollutant load and for sediment movement. An Outline CEMP is provided in Appendix 2A and the measures contained would be implemented during the construction phase of the Proposed Project.

- The main works contractor will develop, in consultation with National Grid, a Site Waste Management Plan (SWMP). An Outline Waste Management Plan is provided as an Appendix to the Outline CEMP.
- A Peat Management Plan has been prepared and will be adhered to by the contractor, this is provided as an Appendix to the Outline CEMP.
- Measures contained in relevant Natural Resources Wales, DEFRA and Environment Agency best practice guidance on the control and removal of invasive weed species will be implemented.
- A Considerate Constructors Scheme will be in place to ensure that everything is done, where practicable, to reduce the effect on the environment and this will include awareness-raising, through toolbox talks, of the sensitivity required should livestock be in close proximity to works.
- Following the completion of all construction works, the land temporarily used within the working area will be fully reinstated as near as practically possible to its former condition where possible or as agreed with landowners and stakeholders in advance (this will include the reinstatement of most stretches of drainage ditches and existing culverts).
- Regarding the protection of groundwater, the CEMP includes the following;
  - The Contractor shall gain the prior agreement of Natural Resources Wales for all shaft and tunnel construction materials, which are likely to come in contact with the groundwater. An inventory of the materials to be supplied and used for construction of the project shall be made available for audit;
  - The Contractor shall implement procedures to prohibit the use of construction materials containing List I substances that come into contact with groundwater and control the use of construction materials containing List II substances that come into contact with groundwater by demonstrating that List II substances do not leach out such as to create groundwater pollution, or otherwise prohibit their use. Tests to demonstrate that listed substances do not leach out of construction materials may need to be conducted in order to satisfy Natural Resources Wales
  - The Contractor shall develop detailed method statements, drawing from previous work and proven techniques and experience, which describe the construction processes and procedures to be used for the main components of the tunnel (shafts, tunnel, culverts, drive site) and define the chemical composition of materials to be used during the construction process.
- Regarding the control of discharge and protection the CEMP includes the following;
  - The Contractor shall not be permitted to make discharges of any kind to watercourses or sewers without the prior written consent of the appropriate authority and shall comply with all their requirements in respect of discharges. Requests for permission to discharge to watercourses or sewers shall be made by the Contractor to Natural Resources Wales, Welsh Water, their Agents, or other appropriate Visual Impact Provision (VIP), Snowdonia Project 30 authorities. Discharges to ground via soakaways shall not be permitted under any circumstances.

10.8.3 Best practice pollution prevention measures have been embedded into the Proposed Project and are detailed within the Outline CEMP. This includes reference to relevant guidance such as the Environment Agency Guidance to “Protect groundwater and prevent groundwater pollution” and the relevant Pollution Prevention Guidelines (PPGs) and Guidance for Pollution Prevention (GPP) documents as examples of best practice. GPP documents are based on relevant legislation and reflect current good practice. The GPP documents have replaced the withdrawn PPGs, however where no GPP is yet available the information provided within the relevant PPGs is still considered as best practice.

10.9 Predicted Impacts During Construction

10.9.1 The potential effects that could arise during the construction phase of the Proposed Project are discussed below. The construction phase is considered separately for the east and west infrastructure locations, and the removal of the existing infrastructure is also considered during the construction phase.

Tunnel Head House, Sealing End Compounds and 400kV Cable (Undergrounding)

Infrastructure Western Side of the Dwyryd Estuary

Impacts on human health

10.9.2 The initial qualitative risk assessment identified construction workers as being at a higher likelihood of risk (Low likelihood and overall Low risk) than adjacent site users (Unlikely and overall Very Low risk) with regards to direct contact with contaminants. Construction workers are considered to have **Low** sensitivity with regard to contamination and adjacent site users a **Medium** sensitivity. The proposed works include significant ground and excavation works and as such the workforce may be in direct contact with soil and groundwater for a short-term period. Similarly, the potential for wind-blown dusts from excavations and stockpiles to impact adjacent site users is also short-term.

10.9.3 The presence of any contamination has the potential to affect the health of construction workers. However, consideration of the embedded mitigation and implementation of a suitable CEMP, including appropriate site-specific risk assessment and use of appropriate PPE will mitigate the effects of contamination, in these regards. It is therefore considered that the effects will be of a **Negligible** magnitude.

10.9.4 The contaminated land qualitative risk assessment also identified an overall Moderate / Low risk for ground gas, to adversely impact construction workers and a Very Low risk for impact to adjacent site users. The workers are again considered to have a **Medium** sensitivity and the adjacent site users a **Low** sensitivity due to the proximity to housing in this area in relation to the infrastructure of the Proposed Project. The potential for anthropogenically generated ground gas is limited across the majority of the Proposed Project alignment as most of the route is located on open undeveloped land. However, the area around the western tunnel shaft is located at a former sewage works and notable made ground may be present. While the greater risks can be considered to be in the vicinity of the proposed western tunnel shaft, including the cable corridor and the temporary access / permanent access, the nature of the majority of the works being below ground, pose the potential for heavier-than-air gasses to concentrate in these areas from both natural and anthropogenic sources. With consideration of the embedded mitigation measures requiring a CEMP and task specific risk assessments to consider the need for hazardous gas monitoring to be carried out within enclosed spaces, the impact is considered to have a **Minor** Adverse magnitude effect.

Impacts on controlled waters

10.9.5 The potential for controlled waters (i.e. surface waters and groundwater) to be impacted by the construction of the tunnel alignment and associated western infrastructure has been identified as at Moderate risk from leaching of contaminants impacting on and migrating within groundwater and a Moderate / Low risk from surface water run off and direct percolation. With regards to the tunnel alignment this will also include the potential for contaminants to be mobilised by the drilling works from exposed faces of the tunnel leaching and resulting in contamination which ‘re-enters’ groundwater through fractures. Controlled water receptors relevant to the Study Area are the Secondary A and Secondary Undifferentiated Aquifers of the superficial alluvium and tidal flood and head deposits respectively, the Secondary Undifferentiated aquifer of the bedrock; and the rivers, streams and Afon Dwyryd and Afon Glaslyn rivers and their associated estuaries

and catchment areas. Within the vicinity of the western side infrastructure, superficial deposits are predominantly not present, however a shallow cover is anticipated associated with the alluvium within the Study Area and to the north west, and the head deposits adjacent to and east of the existing SEC. However, it is generally considered that ground conditions shall comprise thin superficial cover over shallow rock head.

10.9.6 No potable groundwater abstractions are present, and the Study Area is not within an SPZ. The surface waters are within the catchment of the Afon Glaslyn and Afon Dwyryd which are classified as an NNR and in part within the wider SSSI classification (while surface waters are considered a receptor, the assessment of surface waters is included within Chapter 9: Water Resources). On this basis, the groundwaters are therefore considered to have a **Medium** sensitivity and the surface waters a **High** sensitivity. As the western infrastructure lies within an area of ponding surface water with a stream passing through, the potential for the construction works to impact surface waters is present. This is discussed in detail within Chapter 9: Water Resources.

10.9.7 With regards to tunnel leaching it is anticipated, given the depth that flows will be into the tunnel and pumping of ingressing water will be required to control water levels, as such the potential leaching contaminants will be captured within this pumping system (incorporating treatment if required to achieve any discharge consent limits) creating a negligible impact. For the wider impacts, considering the application of the embedded mitigation and implementation of a suitable CEMP, the impact is considered to have a **Minor** Adverse magnitude of effect for groundwater. The effect on surface waters is discussed in detail in Chapter 9: Water Resources.

10.9.8 Chemical, fuel and oil spillages during the construction phase could result in the contamination of controlled waters (with **High** sensitivity) though leakage or leaching of chemicals such as fuels, lubricants and solvents. Spills could occur through improper storage and accidental spillages of potentially hazardous substances presenting a hazard to controlled waters. Tracks and compounds where vehicles are re-fuelled or on stand-by and areas of chemical and hydrocarbon storage, are additional potential sources of contamination. The provision of hardstanding / impermeable surfacing / bunding in these areas will reduce the risk to groundwater. It is anticipated that the main storage areas are expected to be within construction compounds at the two tunnel shafts rather than located across the whole of the construction area and are likely to be located within the western end as this is the location of the start of the drilling. The embedded mitigation measures detail the requirement for a CEMP which would address the potential contamination risks resulting from spillages during the construction. With the implementation of the embedded mitigation outlined there would be a **Negligible** potential impact.

Reuse of waste arisings

10.9.9 The tunnel boring machine will be launched from the western shaft. This tunnel shaft will also therefore be used for removing excavated waste and spoil material from the excavation as well as the stockpiling and supply of materials to the tunnel construction. As noted in Section 10.5.75 initial assessment has been made of the potential tunnel arisings and their potential for pyrite and associated acid rock drainage (ARD) has been undertaken.

10.9.10 The reuse of this material is not included within this Chapter. The intended reuse of materials within the scheme is not currently known. However, should the material be reused, the appointed contractor should incorporate suitable testing, management and mitigation measures to address the points raised within the AECOM report and the potential for pyrite related acid rock drainage (ARD) detailed in the assessment undertaken by Stantec.

Impacts on ecological receptors

10.9.11 The initial qualitative assessment identified a Very Low potential risk to ecological receptors from site contamination in the area of the western infrastructure and tunnel alignment. The ecological receptors within the vicinity of the western infrastructure include the Ysbyty Bron Y Garth SSSI and Lleyn Peninsula and the Sarnau SAC which encompasses the existing SEC area. These ecological receptors are fed by surface waters located within the Study Area which also relate to the wider Morfa Harlech SSSIs and NNR of the estuaries of the Afon Dwyryd and Afon Glaslyn. These surface waters may be in part base-fed from shallow groundwater as springs are noted in elevated areas to the east within the Study Area and may potentially source a number of the streams feeding the estuaries within the Study Area. The tunnel alignment passes thorough the Morfa Harlech SSSI and Lleyn Peninsula and the Sarnau SAC and enters the Snowdonia National Park towards the eastern side of the Afon Dwyryd. As such the value of the receptor is **High**. With the consideration of the embedded mitigation, including the requirement for the CEMP and the process to control run-off outlined in Chapter 2: Project Description, together with the significant depth below ground of the alignment section, the magnitude of potential impact would be reduced to **Negligible**. Specific mitigation requirements for ecological receptors are discussed in Chapter 7: Ecology of this Environmental Appraisal.

10.9.12 There is also a potential impact to sensitive ecological receptors from stability hazards, i.e. subsidence, landslide, as a result of earthworks and the installation of permanent underground structures. The geology / geomorphology is considered to have a **High** sensitivity due to the SSSI status. The GroundSure Report identified a maximum high hazard rating for collapsible rocks and a variable risk between moderate and very low for landslides, shrink-swell ground and compressible ground, all of which were identified at localised parts of the Study Area. The tunnel is anticipated to be between 32mbgl and 73.5mbg deep and 4.4m wide. With the consideration of the nature of the works, and the embedded mitigation including the detailed requirements of the CEMP, the magnitude of the impact on this basis is likely to be **Negligible** with regards to ecology.

10.9.13 The site soils are considered to have a **High** sensitivity due to the SAC, SSSI and NNR status of the surrounding land. Chemical, fuel and oil spillages during the construction phase could result in the contamination of soils and waters though leakage of chemicals such as fuels, lubricants and solvents. Spills could occur through improper storage and accidental spillages of potentially hazardous substances presenting a hazard to the soils and controlled waters. Tracks and compounds where vehicles are re-fuelled or on stand-by, spoil storage, and areas of chemical and hydrocarbon storage, are additional potential sources of contamination. As discussed previously it is expected that tunnel boring shall start at the western tunnel shaft and as such the compound at this end shall include additional storage areas for arisings and supplies. The embedded mitigation measures detail the requirement for a CEMP which will address the potential contamination risks resulting from spillages during the construction. With these taken into account the magnitude of the effect is considered to be **Negligible**.

10.9.14 There is the potential for soils (**High** sensitivity) to be impacted by existing made ground in the Study Area. The potential for made ground at the location of the western infrastructure has been identified predominantly associated with a former sewage works within the tunnel shaft footprint. The cable alignment in this area also passes close to the former slate quarry yard also with associated artificial ground noted. The presence and composition of made ground and / or fill at other areas of the route is unknown but within the majority of the Study Area made ground is considered unlikely due to the broadly green-field nature. The relevant embedded mitigation measures including the CEMP would take into account the protection of the soils. The project design, in Chapter 2: Project Description, outlines the implementation of the construction areas and their

return to natural ground and as such the works are likely to have a **Negligible** magnitude effect on soils.

10.9.15 There is the potential for damage to soils (**High** sensitivity) during excavation works from disturbance during excavation, compaction and backfilling, unstable excavations and erosion of soils from potential groundwater ingress, especially if groundwater is perched within the shallow superficial deposits and within shallow bedrock groundwater encountered in the tunnel shaft. Relevant embedded mitigation measures and the CEMP, including dewatering of the works detailed in Chapter 2: Project Description, the installation of secant walls to prevent ingress of waters and subsequent filtration of extracted waters and limiting of excavation works in periods of adverse weather, will result in a **Negligible** impact magnitude effect.

Impacts to building, structures and services

10.9.16 Existing buildings are considered to have a **Low** sensitivity overall as the sparse off-site residential properties adjacent to the western infrastructure, are considered unlikely to be impacted by construction works. With the relevant embedded mitigation measures in place and the inclusion of consideration for nearby property taken account of within CEMP, the works should have a **Minor** adverse magnitude effect.

10.9.17 The initial qualitative assessment identified a Low risk to the Proposed Project (**Medium** sensitivity) from ground contamination. The risk from ground contamination would be reduced by the embedded mitigation and the controls set out in the CEMP to mitigate the risk from accidental spills during construction. This would result in a **Minor** adverse magnitude effect**.**

10.9.18 There is also a potential impact from the instigation of stability hazards, i.e. subsidence, landslide, as a result of earthworks and the installation of permanent underground structures. The buildings, structures and services are considered to have a **medium** sensitivity. The GroundSure Report identified a maximum high hazard rating for collapsible rocks and a variable risk between moderate and very low for landslides, shrink-swell ground and compressible ground, all of which were identified at localised parts of the Study Area. The tunnel is anticipated to be between 32mbgl and 73.5mbg deep and 4.4m wide. With the consideration of the design and embedded mitigation including the detailed requirements of the CEMP, the magnitude of the impact on this basis is likely to be **Negligible** with regards to the buildings, structures and services of the Proposed Project.

10.9.19 A Moderate / Low risk to the proposed infrastructure (**Medium** sensitivity) was identified from the effects of ground gas. The potential for made ground is most present in the area of the western infrastructure, associated with the former sewage works, however the Moderate / Low risk is largely related to the unknown ground gas regime for the scheme and the presence of made ground and / or fill across the majority of tunnel alignment is considered unlikely, due to the broadly green-field nature of the Study Area as a whole, the potential composition of the made ground is unknown. With consideration of the embedded mitigation measures and those in the CEMP, the impact is considered to have a **Minor** magnitude effect.

Impacts on resource receptors

10.9.20 The initial qualitative assessment identified a Very Low risk potential for impact on the potential mineral resources within the Study Area. As discussed previously, mineral resources are identified within the Study Area including the majority of the Study Area being noted as a potential slate resource with recorded workings and a band of igneous rock (Dolerite) at the location of the Garth Quarry with associated sandstone band outside of the Study Area.

10.9.21 Peat is noted within a small area to the north west of Penrhyndeudraeth on the boundary of the Study Area.

10.9.22 These receptors are therefore considered to have a **Medium** sensitivity. It is noted that mineral extraction in the Study Area is likely to be constrained by the high ecological value of the area and therefore it is considered to be unlikely that new quarries or extractions would gain consent. The Garth Quarry is up hill from the Proposed Project and over 110m from the Garth SEC. The area of geological resources that are likely to be impacted by the installation of tunnel and tunnel shafts, is considered minor compared to the total size of the resource, thus the magnitude of the effect is considered to be **Low** Adverse.

Impacts on hydrogeology

10.9.23 The hydrogeological CSM identified that the Proposed Project has the potential to disrupt the hydrogeological pathways of the site and therefore potentially impact the groundwater, surface water and ecological receptors.

10.9.24 The construction of the tunnel and the tunnel shafts will require the dewatering of the excavations and the pumped water will be discharged following any required treatment. This removal and/or interference with the shallow groundwater may potentially create a drawdown effect within the groundwater with the potential to impact the volume and flow rate of surface water streams and saltmarsh and the associated sensitive ecological receptors.

10.9.25 However, the final shaft depth will be between 39.5 and 73.5m deep and therefore the pumping of any near-surface groundwater ingress would occur only during the initial drilling of the shaft. As the construction of the shaft progresses, pumping of any groundwater ingress would occur at progressively lower depths, until the ultimate construction depth of the shaft is reached. At this depth, and given the anticipated volume and rate of pumping, it is unlikely that the transmissivity of the geology above the ultimate tunnel and shaft base elevation would be sufficient to allow a drawdown effect that could impact surface water features and any impact would inherently be temporary.

Infrastructure Eastern Side of the Dwyryd Estuary

Impacts on human health

10.9.26 The potential effect to construction workers and adjacent site users with regards to direct contact with contaminants including wind-blown dusts is considered to be relatable to that of the Western Infrastructure (as above) and as such the effects are considered to be of **Negligible** magnitude effect on either receptor.

10.9.27 The potential for ground gas to adversely impact construction workers adjacent site users is considered to be the same as for the Western Infrastructure (as above) and therefore there is considered to be a potential **Minor** Adverse magnitude effect.

Impacts on controlled waters

10.9.28 The potential for controlled waters (i.e. surface waters and groundwater) to be impacted by the construction of the eastern infrastructure is considered to be similar as for the Western Infrastructure although the controlled water receptors relevant to the Study Area are the Secondary Undifferentiated Aquifers of the superficial strata and bedrock, the small rivers and streams and the Afon Dwyryd and its associated estuary and catchment area. As with the Western Infrastructure, no potable groundwater abstractions or SPZ are present. The surface waters are within the catchment of the Afon Dwyryd which is classified as an NNR and in part within the wider SSSI classifications for the area, as well as the eastern infrastructure being within the Snowdonia National Park (while surface waters are considered a receptor the assessment of surface waters is covered

within Chapter 9: Water Resources). Springs are noted to the east of the Study Area and it is likely that streams in this area are at least in part fed from groundwater above the elevation of the Proposed Project. On this basis the groundwaters are therefore considered to have a **Medium** sensitivity and the surface waters a **High** sensitivity. As the eastern infrastructure lies within an area where a stream flows through an area of long grasses and ponding surface water, the potential for the construction works to impact surface waters is present. This is discussed in detail within Chapter 9: Water Resources. Considering the application of the embedded mitigation and implementation of a suitable CEMP, the impact is considered to have a **Minor** Adverse magnitude effect for groundwater. The effect on surface waters is not covered in this section and discussed in detail within Chapter 9.

10.9.29 Regarding the potential for chemical, fuel and oil spillages during the construction phase, this is considered to be similar as for the Western Infrastructure although it is anticipated that the main storage areas are expected to be located within the western end as this is the location of the start of the drilling. The embedded mitigation measures detail the requirement for a CEMP will address the potential contamination risks resulting from spillages during the construction. With the implementation of the embedded mitigation outlined there would be a **Negligible** magnitude of potential impact.

Waste assessment

10.9.30 The majority of the arisings will pass through the western infrastructure construction area as this is the location of the start of tunnelling however it is likely that there shall be some arisings stored within the eastern construction area also. The assessment within the western infrastructure section also relates to the eastern infrastructure area.

Impacts on ecological receptors

10.9.31 The initial qualitative assessment identified a Very Low potential risk to ecological receptors from site contamination in the area of the eastern infrastructure and tunnel alignment. The ecological receptors within the vicinity of the eastern infrastructure include the Snowdonia National Park with Morfa Harlech SSSI and Lleyn Peninsula and the Sarnau SAC and NNR of the Afon Dwyryd estuary to the west. As such the value of the receptor is **High**. With the consideration of the embedded mitigation, including the requirement for the CEMP and the processed to control run-off, outlined in Chapter 2: Project Description, the magnitude of potential impact may be reduced to **Negligible**. Specific mitigation requirements for ecological are discussed in Chapter 7: Ecology, of this Environmental Appraisal.

10.9.32 The potential impact to sensitive ecological receptors from stability hazards, i.e. subsidence, landslide, as a result of earthworks and the installation of permanent underground structures is considered to be as the western side of the Dwyryd Estuary With the consideration of the nature of the works, and the embedded mitigation including the detailed requirements of the CEMP, the magnitude of the impact on this basis is likely to be **Negligible** with regards to ecology.

10.9.33 As with the western side of the Dwyryd Estuary, the embedded mitigation measures detail the requirement for a CEMP which will address the potential contamination risks resulting from spillages during the construction. With these taken into account the magnitude of the effect is considered to be **Negligible**.

10.9.34 Regarding the potential for soils (**High** sensitivity) to be impacted by existing made ground in the Study Area, as with the western side of the Dwyryd Estuary, the relevant embedded mitigation measures including the CEMP should take into account the protection of the soils. The project design, in Chapter 2: Project Description, outlines the implementation of the construction areas and their return to natural ground and as such the works are likely to have a **Negligible** magnitude effect.

10.9.35 Regarding the potential for damage to soils (**High** sensitivity) as with the Western Infrastructure the implementation of embedded mitigation measures and the CEMP, including dewatering of the works, the installation of secant walls to prevent ingress of waters, and subsequent filtration of extracted waters and limiting of excavation works in periods of adverse weather, will result in a **Negligible** impact magnitude effect.

Impacts to building, structures and services

10.9.36 The impacts to building, structures and services are considered relatable to those for the western infrastructure and as such the effects are considered the same. (Please refer to the western infrastructure section).

Impacts on resource receptors

10.9.37 The initial qualitative assessment identified a Very Low risk potential for impact on the potential mineral resources within the Study Area. Mineral resources are identified within the Study Area including the majority of the Study Area being noted as a potential 'slate resource with recorded workings' which is the most relevant to the eastern infrastructure area.

10.9.38 These receptors are therefore considered to have a **Medium** sensitivity. It is noted that mineral extraction in the Study Area is likely to be constrained by the high ecological value of the area and therefore it is considered to be unlikely that new quarries or extractions would gain consent. The area of geological resources that are likely to be impacted by the installation of tunnel and tunnel shafts, is considered minor compared to the total size of the resource, thus the magnitude of the effect is considered to be **Low** Adverse.

Impacts on hydrogeology

10.9.39 The impacts upon hydrology for the eastern infrastructure are considered comparable to that for the western infrastructure and as such the effects are considered the same (Please refer to the western infrastructure section).

Removal of Existing Infrastructure (VIP subsection)

Impacts on human health

10.9.40 Works will involve the removal of pylons and foundations to 1.5m depth in line with the Project Description in Chapter 2. With regards to direct contact with contaminants including wind-blown dusts construction workers and adjacent site users were assessed above to be at a Low and Very Low risk respectively. With the exception of pylons 4ZC034 and 4ZC033 which have nearby housing, the majority are located within open land with limited adjacent site users. As the nature of the made ground at the locations of the pylons is not known, with the application of the embedded mitigation and the emplacement of a suitable CEMP, the impact is considered to have a **Minor** adverse magnitude effect.

Impacts on controlled waters

10.9.41 Groundwater is considered to have a **Medium** sensitivity and surface water are considered to have a **High** sensitivity, associated with the pylons crossing SSSIs and the NNR and Snowdonia National Park onsite. Spillages during the removal of existing infrastructure (potential from cranes and vehicles used and the laydown area) could result in the contamination of controlled waters though leakage or leaching of chemicals, most notably as a number of the pylons lie on the saltmarsh and within the estuary. However, with the implementation of the embedded mitigation including the CEMP these

risks will be reduced and therefore, are considered to have a **Minor** magnitude of effect with regards to groundwater.

Reuse of waste arisings

10.9.42 It is currently anticipated that arisings from the tunnel excavation may be utilised in the infilling of the voids left by the removal of the pylon foundations. For consideration of the arising material see Section 10.9.9.

Impacts on ecological receptors

10.9.43 The initial qualitative assessment identified a Moderate potential risk to ecological receptors from site contamination. The ecological receptors include designations of national importance (SSSI, NNR and Snowdonia National Park) and as such the value of the receptor is **High**. With the consideration of the embedded mitigation including the requirement for a suitable CEMP, and the controls for run-off and dust generation detailed in the design in Chapter 2: Project Description, the magnitude of potential impact is reduced to **Negligible**. Specific mitigation requirements for ecological are discussed in Chapter 7: Ecology of this Environmental Appraisal.

10.9.44 As the ground will be excavated to remove concrete foundations, there is a potential impact from instigation of stability hazards during ground excavations. The geology is again considered to have a **High** sensitivity due to the SSSI, NNR and National Park status. A variable hazard rating was identified, in the GroundSure Report, along the line of the pylons to be removed typically rated low to medium. Based upon this and the limited nature of the works for the removal of the pylons, the magnitude of the impact is likely to be **Negligible**.

10.9.45 Spillages during removal of the pylons could result in the contamination of soils of **High** sensitivity. This is most likely to occur from cranes and other vehicles that will be used during works, and any chemicals stored in the laydown areas. The embedded mitigation measures detailed and the requirement for a CEMP, when taken into account would present a **Negligible** magnitude effect.

10.9.46 There is also the potential for soils to be impacted by existing made ground in the Study Area. Within the location of the pylons, no previous development has been identified. As such the potential made ground at the site is likely to be limited to the installation of the pylons themselves. As such the works to remove the pylons are considered to have a **Negligible** magnitude impact on existing soils.

10.9.47 There is the potential for damage to soils of **High** sensitivity during excavation works to remove foundations. Relevant embedded mitigation measures, including dewatering and limiting of excavation works in periods of adverse weather outlined within the embedded mitigation, and the proposed design in Chapter 2: Project Description, will result in a **Negligible** magnitude impact.

Impacts on existing buildings and structures

10.9.48 The existing structures are to be removed and there is a lack of notable nearby structures. As such no complete potential pollution (impact) linkage is considered present.

Impacts on resource receptors

10.9.49 The initial qualitative assessment identified a Very Low risk potential for impact on the potential mineral resources within the Study Area. As noted previously, mineral extraction in the Study Area is likely to be constrained by the high ecological value of the area and therefore it is considered to be unlikely that new quarries or extractions would gain consent. However, the removal of the pylons and foundations has the potential to

increase the access to the resource for future exploitation of resources in the area. Therefore, a potential beneficial effect may be recognised, although the area of geological resource that is likely to be impacted by the removal of the pylons is negligible, thus the magnitude of the effect is considered to be **Negligible**.

Impacts on hydrogeology

10.9.50 No potentially complete impact linkages have been identified to the site's hydrogeology during the removal of the existing pylons or OHL.

10.10 Predicted Impacts During Operation

10.10.1 The sensitivity of the receptors and magnitude of potential effects that could arise during the operational phase of the Proposed Project (as defined for geomorphology and hydrogeology in Tables 10-2 and 10-3) are discussed below. It is noted that, as the temporary facilities including works areas, storage, haul roads etc. will be removed at the end of the construction phase, no operational or decommissioning phases would be involved for these components of the Proposed Project.

Tunnel Head House, Sealing End Compounds and 400kV Cable (Undergrounding)

Infrastructure Western Side of the Dwyryd Estuary

10.10.2 The only operational elements of the western infrastructure shall be the tunnel head house, the existing Garth SEC, associated facilities and the pylons and connections and only minor inspection or repair works would be anticipated during their operational lifetime.

10.10.3 Use, storage, emissions and accidental spillages of potential contaminants during these operations are likely to be limited and infrequent. It is anticipated that such works should be undertaken in accordance with best practice and appropriate risk assessments undertaken for the works. With the implementation of these measures it would be considered that the magnitude of the effects of the operation of the western infrastructure on the site receptors would be **Negligible**.

Infrastructure Eastern Side of the Dwyryd Estuary

10.10.4 The only operational elements of the eastern infrastructure shall be the tunnel head house, eastern SEC, pylons and connections. It is considered that the potential impacts and subsequent effects of the operation of the eastern infrastructure shall be equivalent to that of the western side infrastructure detailed above (Section 10.10.2).

Removal of Existing Infrastructure (VIP subsection)

10.10.5 It is anticipated that the removal of the existing OHL and associated pylons would pose a **negligible** magnitude effect upon the site receptors.

10.10.6 The reduction in the need to access the pylons and OHL for maintenance and observation works as noted in (Section 10.10.2) would eliminate the potential for emissions and accidental spillages of potential contaminants across the route and as such a beneficial effect can be assumed.

10.11 Predicted Impacts during Decommissioning

Tunnel Head Houses, Sealing End Compounds and 400kV Cables (Undergrounding)

10.11.1 The sensitivity of the receptors and magnitude of potential effects that could arise during the decommissioning phase of the Proposed Project (as defined for geomorphology and hydrogeology in Tables 10.2 and 10.3) are outlined below.

10.11.2 The decommissioning activities include the removal of the Proposed Project, i.e. transmission medium from the tunnel, SEC and terminal pylon, tunnel head houses, tunnel, cabling and permanent access.

Assessment of impacts during the decommissioning of the Sealing End Compounds terminal pylon, transmission medium and permanent access

10.11.3 This Environmental Appraisal assumes these parts of the Proposed Project would be removed if no longer required, with the foundations removed to a depth of approximately 1.5m. Potential impacts are therefore likely to be similar but on a smaller scale than the construction phase. These impacts can be managed as per measures during the construction phase and with reference to any new guidance and legislation that may be in place at the time of decommissioning.

Assessment of impacts during the decommissioning of the tunnel head houses, tunnel and cabling

10.11.4 If the connection is no longer required, unless there was a compelling need for removal of the underground sections, the buried sections of cable would remain buried in the ground, it is likely that cables in the tunnel would be removed. The tunnel head houses, if required, could be demolished and the constituent materials taken away for recycling. The foundations would be removed up to 1m below ground level (unless a compelling reason to remove entirely). The potential impacts are therefore likely to be similar but on a smaller scale than the construction phase. These impacts can be managed as per measures during the construction phase and with reference with any new guidance and legislation that may be in place at the time of decommissioning.

10.11.5 It is appreciated that a considerable sum of resources would have been expended to construct the tunnel and shafts, therefore a highly compelling reason would need to be found for decommissioning. However, if it is decided to decommission then the shafts and tunnel can be either capped off at the top of the shafts and flooded with water or filled with foamed concrete, depending on the situation at that time. The potential risk shall therefore be driven by the choice of decommissioning but also likely to be similar but on a smaller scale than the construction phase.

10.12 Mitigation and Summary of Residual Effects

10.12.1 The embedded mitigation measures to address the potential effects over the lifetime of the Proposed Project from construction, operation and decommissioning are detailed in Section 10.8.

10.12.2 The assessment of predicted effects in Section 1**Error! Reference source not found.**.9 to Section 10.11 identified the following potential residual risks;

During Construction

- Infrastructure East and West side - A potential residual risk relating to the impact of contamination / chemical conditions on buildings, structures and services.
- Infrastructure East and West side - A potential residual risk relating to the hazardous accumulation of ground gas on human health and on buildings,

structures and services was identified. The effect mainly relates to the potential for gas producing made ground at the former sewage works. However, with the presence of organic soils within the Study Area, the waterlogged nature of the two infrastructure areas, and the adjacent current water treatment works to the eastern infrastructure, the effect can be considered across the two areas.

10.12.3 It is recommended that a suitable ground investigation is undertaken to ascertain the ground conditions at the Proposed Project areas including the assessment of soil conditions and a suitable programme of gas monitoring to ascertain the gas regime. The investigation should also include the assessment and potential remediation of contamination encountered.

10.12.4 Suitable materials should be adopted for the underground structures based upon the further investigation which would reduce the magnitude of effect to Negligible. Similarly the implementation of suitable mitigation measures employed in the construction, based upon the gas regime, would reduce this effect to a Negligible magnitude. Should remedial works be required, notably regarding the former sewage works, a positive effect could be attained by the removal of made ground and contaminated materials, which would also positively impact the other receptors.

During Operation

10.12.5 No residual effects have been identified for the Proposed Project during the operational phase.

During Decommissioning

10.12.6 No residual effects have been identified for the Proposed Project during the decommissioning phase.