LLŶR

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 6: Appendix 3A – Cable Route Assessment

August 2024

Prepared by: Llŷr Floating Wind Ltd

FLOVENTIS ENERGY

Document Status

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Prepared for	Llŷr Floating Wind Limited
Approved by	Jay Hilton-Miller

Acronyms and abbreviations

Acronym or abbreviation	Definition	Acronym or abbreviation	Definition
CBRA	Cable Burial Risk Assessment	META	Marine Energy Test Area
CEFAS	Centre for Environment, Fisheries and Aquaculture Science	MOD	Ministry of Defence
EIA	Environmental Impact Assessment	MW	Megawatt
EUNIS	European Nature Information System	NGET	National Grid Electricity Transmission
FLOW	Floating Offshore Wind	O&M	Operation & Maintenance
HDD	Horizontal Directional Drilling	OTNR	Offshore Transmission Network Review
HND	Holistic Network Design	PLGR	Pre-lay Grapnel Run
HVAC	High Voltage Alternating Current	SAC	Special Area of Conservation
ICES	International Council for the Exploration of the Sea	SPA	Special Protection Area
JNCC	Joint Nature Conservation Committee	SSSI	Site of Special Scientific Interest
KM	Kilometres	TBT	Tributyltin
kV	Kilovolts	TCE	The Crown Estate
LAT	Lowest Astronomical Tide	TJB	Transition Joint Bay
M	Metres	UXO	Unexploded Ordinance
MCZ	Marine Conservation Zone		

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EXECUTIVE SUMMARY

This report has assessed the hard and soft environmental and engineering constraints, both offshore and at landfall, for an export cable corridor located inside the Llŷr [*offshore*] survey area. The study considers a 300 m wide export cable corridor as this can generally be maintained between the boundary of the Llŷr [*offshore*] survey area and the indicative route of the Project Erebus export cable(s) although the width available within the Llŷr [*offshore*] survey area does narrow to approximately 270 m in one location.

Industry best practice would be to obtain consent for a 500 metre wide export cable corridor which maintains a separation distance with an adjacent corridor which is sufficient to affect a cable repair (typically this would be, say, 150 m between the Project Llŷr and Project Erebus offshore export cables to include an error allowance). This could be achieved whilst remaining within the Llŷr Offshore Project Boundary but would require the extent of the Llŷr [*offshore*] survey area to be increased. It is recommended that consideration is given to widening the survey area to obtain consent for a wider corridor and achieve a separation distance from the Project Erebus export cables which allows for cable repair and micro-siting within the respective corridors.

A single offshore crossing of the Greenlink Interconnector will be needed if landfall occurs either at West Angle Bay or west of the Greenlink Interconnector landfall site. The crossing of the Greenlink Interconnector will occur within the Annex I Habitat identified as Turbot Bank Sandbank. The use of rock bags at this crossing location will keep the rocks contained, mitigating the risk of the rocks spreading across the sandbank. Such a solution will require further evaluation through consultation with Greenlink and NRW. Where the Project Llŷr export cables pass through the remainder of this sandbank, burial avoiding pre-sweeping or external cable protection is considered preferable as this will minimise disturbance to the seabed, which could result in physical change as well as permanent habitat loss.

For landfall at Freshwater West, the offshore cable corridor identified approaches landfall via a sandy-clay channel, between rocky-subcrop. Detailed analysis of the boulder field here will be required to understand exact routing and whether extensive boulder clearance will be required. From the boulder field, the offshore corridor will then pass through an area of Megaripples and then south of the Bombora Wavepower and META areas. If the Freshwater West landfall site is chosen a study will also be required to determine the extent of separation from the Greenlink Interconnector in the nearshore area on the approach to landfall.

1 INTRODUCTION

1.1 The Development

Llŷr Floating Wind Limited (hereafter referred to as the Applicant) is proposing to develop the Llŷr 1 Floating Offshore Wind Farm, (hereafter referred to as the proposed Project), located 35 kilometres (km) from the northeastern corner of the Array Area to Linney Head (the closest location on the coast of Pembrokeshire) in the Celtic Sea.

Project Llŷr has emerged through The Crown Estate's (TCE) Test & Demonstration leasing opportunity, created to support the development and commercialisation of pioneering, floating wind technologies. Each of the Project Llŷr developments will test different floating platform and mooring technologies and explore innovative designs, materials, and construction methodologies.

Project Llŷr is categorised as a Schedule 2 development under The Marine Works (Environmental Impact Assessment (EIA)) Regulations 2007 (as amended) and The Electricity Works (EIA) (England and Wales) Regulations 2017 (as amended).

Each Project Llŷr development will export electricity to an onshore connection point through a single circuit. Llŷr Floating Wind Limited has secured a point of connection at National Grid's Pembroke Substation and are awaiting final details of this offer. The basis for this study is that the connection point offered is Pembroke Substation.

1.2 BlueGem Wind

BlueGem Wind (BGW) are also planning a floating offshore wind development of up to 100 MW in the Celtic Sea. The array area for their development, known as Project Erebus, is located to the northwest of the proposed Project Llŷr array areas, refer to **Figure 1-1**. BGW has now received a Marine Licence and a Section 36 consent. Their offshore cable corridor is referred to as the Project Erebus export cable corridor in this study.

1.3 Project Llŷr Scoping Report

The Project Llŷr Scoping Report, which was submitted in April 2022, identified both an onshore scoping boundary and offshore project boundary for the Llŷr developments. These boundaries represent the maximum extent of the development area. Within the Llŷr Offshore Project Boundary, Llŷr Floating Wind Limited has defined a Llŷr [offshore] survey area. The extent of this survey area is referenced in **Figure 2-1**.

1.4 Aim of this Study

The aim of this study is to identify and evaluate an offshore export cable corridor located within the Llŷr [offshore] survey area for each of the two preferred landfall sites, West Angle Bay and Freshwater West.

1.5 Legislation and Guidance

This study takes cognisance of the statutory procedures set out in the following regulations:

- The Electricity Works (EIA) (England and Wales) Regulations 2017 (the Electricity Works EIA Regulations); and
- The Marine Works (EIA) Regulations 2007 (the Marine Works EIA Regulations).

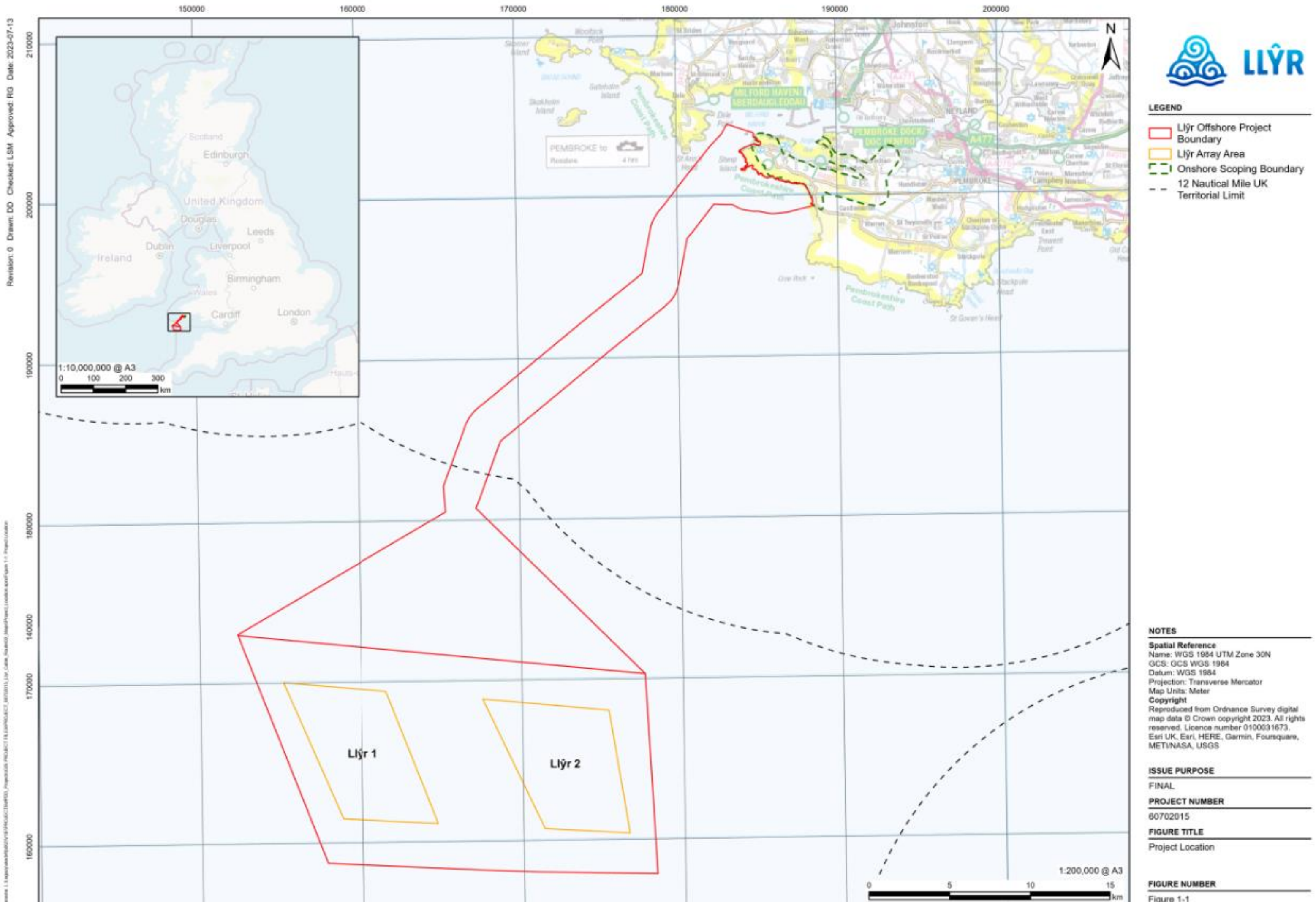

Figure 1-1.Project location

2 IDENTIFICATION AND EVALUATION OF AN OFFSHORE EXPORT CABLE CORRIDOR

2.1 Project Erebus Offshore Export Cables

Project Erebus has obtained consent for an offshore export cable corridor between their array area, to the north west of the Project Llŷr array area and West Angle Bay; refer to **Figure 2-5.**

This corridor:

- varies in width between 100 m within Row's Rocks Channel (located within the approach to Milford Haven) and 450 m along the majority of their export cable corridor; and
- enters the Llŷr [*offshore*] survey area approximately 3 km south of the 12 nautical mile UK territorial limit and then remains within this survey area all the way to their landfall site at West Angle Bay.

Within their export cable corridor, Project Erebus plan to lay either a single, 3 core HVAC 66 kV, subsea cable or a pair of 3 core HVAC 66 kV, subsea cables bundled together. The length of their export cable is estimated to be 49 km.

2.2 Greenlink Interconnector Offshore Cables

The Greenlink Interconnector is a subsea interconnector linking EirGrid's Great Island Substation in County Wexford and National Grid's Pembroke Substation in Pembrokeshire. Planning consent has been granted for the scheme and construction work commenced in 2023.

In order to remain within both the Llŷr Offshore Project Boundary and the Llŷr [*offshore*] survey area the Llŷr offshore export cable corridor must cross the Greenlink Interconnector prior to landfall; the Llŷr Offshore Project Boundary precludes an option that allows the Llŷr offshore export cable corridor to remain entirely south of the Greenlink Interconnector before landfall.

2.3 Project Llŷr Offshore Export Cables

Each Project Llŷr array area will export electricity to the point of connection through a single circuit comprising a single, 3 core HVAC 66 kV, subsea cable. Llŷr Floating Wind Limited propose using the same export cable corridor for both cables and that the cables are laid in separate trenches as opposed to being bundled together. A fibre optic cable will also run alongside each cable to facilitate remote monitoring and control of the array.

2.4 Project Llŷr Export Cable Corridor Search Area

The extent of the search area for the Project Llŷr offshore export cable corridor is constrained by the project requirement to remain within the Llŷr [*offshore*] survey area.

2.5 Project Llŷr Export Cable Corridor Identification

The aim of this study has been to identify a technically feasible and economically viable export cable corridor which limits disturbance to the environment and disruption to human activity whilst minimising cable length. Initial identification of a corridor was based on the requirements too:

- remain within both the Llŷr Offshore Project Boundary and the Llŷr [*offshore*] survey area;
- avoid where possible, or otherwise minimise, the distance through which the route crosses reef habitat, including within the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation

(SAC);
- avoid where possible, or otherwise minimise, the distance through which the route crosses the Ministry of Defence (MOD) Castlemartin Range Sea Danger Area;
- minimise disruption to shipping associated with Milford Haven and offshore traffic separation schemes;
- minimise the number of existing pipeline and cable crossings as far as possible; and, where a crossing is required, cables and pipelines are crossed at 90 degrees where possible; and
- avoid other infrastructure, dredging areas, disposal areas etc, with suitable buffers.

Through consideration of these requirements, the corridor shown in **Figure 2-1** was identified. This corridor, which is shown as being 300 m wide so as to both remain within the Llŷr [*offshore*] survey area and avoid the indicative route of the Project Erebus export cable(s), has one variant leading to the south landfall at West Angle Bay [*overall corridor length approximately 43 kilometres*] and another leading to the landfall west of the Greenlink Interconnector at Freshwater West [*overall corridor length approximately 45 kilometres*]. Generally, the corridor follows the eastern edge of the Llŷr [*offshore*] survey area to minimise the extent of interaction with the Project Erebus export cable(s) [*approximately 19 kilometres of the Llŷr offshore cable corridor overlaps with the Project Erebus cable*].

2.6 Project Llŷr Export Cable Corridor Evaluation

The corridor and associated variants for the 2 landfall sites were then evaluated against a range of physical, environmental and human factors. These included:

- Seabed geology and surface sediments, conditions and geohazards;
- Pipelines and cables, including Project Erebus ad Greenlink;
- Renewable energy sites e.g., windfarms and wave energy;
- Ports and anchorage areas;
- Shipping;
- Commercial fishing e.g., fish farms;
- Cultural heritage e.g., wrecks;
- Military areas;
- Dumped munitions and Unexploded Ordnance (UXO);
- Aggregate extraction sites;
- Disposal areas and dredging;
- Protected sites e.g., SAC, Special Protection Area (SPA), Site of Special Scientific Interest (SSSI), Ramsar sites, and Marine Conservation Zones (MCZ);
- Annex I Habitats;
- Benthic Habitats; and
- Fish spawning and nursing grounds.

The comparative evaluation of corridors making landfall at Freshwater West and West Angle Bay is presented in **Table 2-1**.

The following Figures illustrate the various constraints within the corridor:

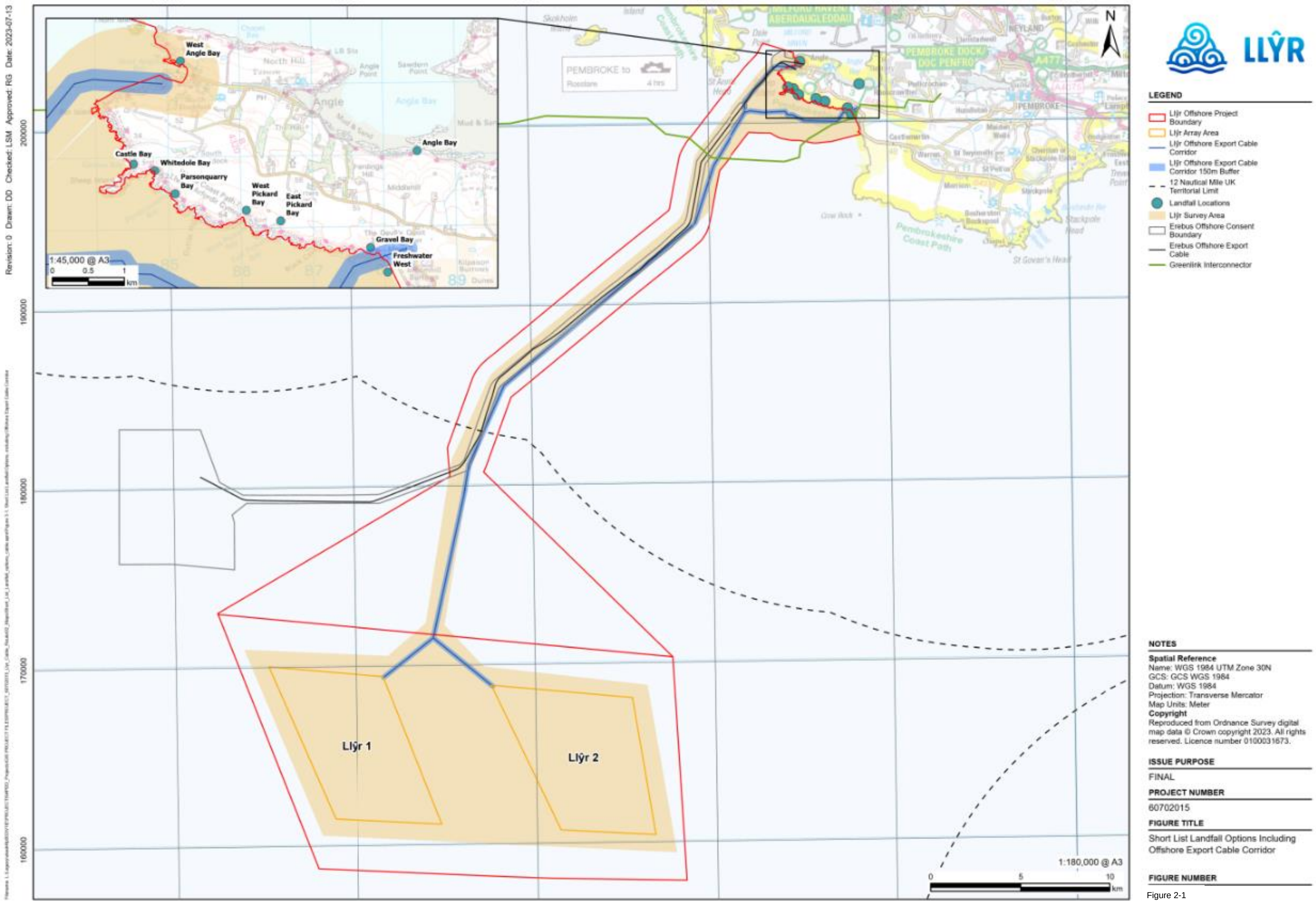

Figure 2-1. Short List Landfall Options, including Offshore Export Cable Corridor

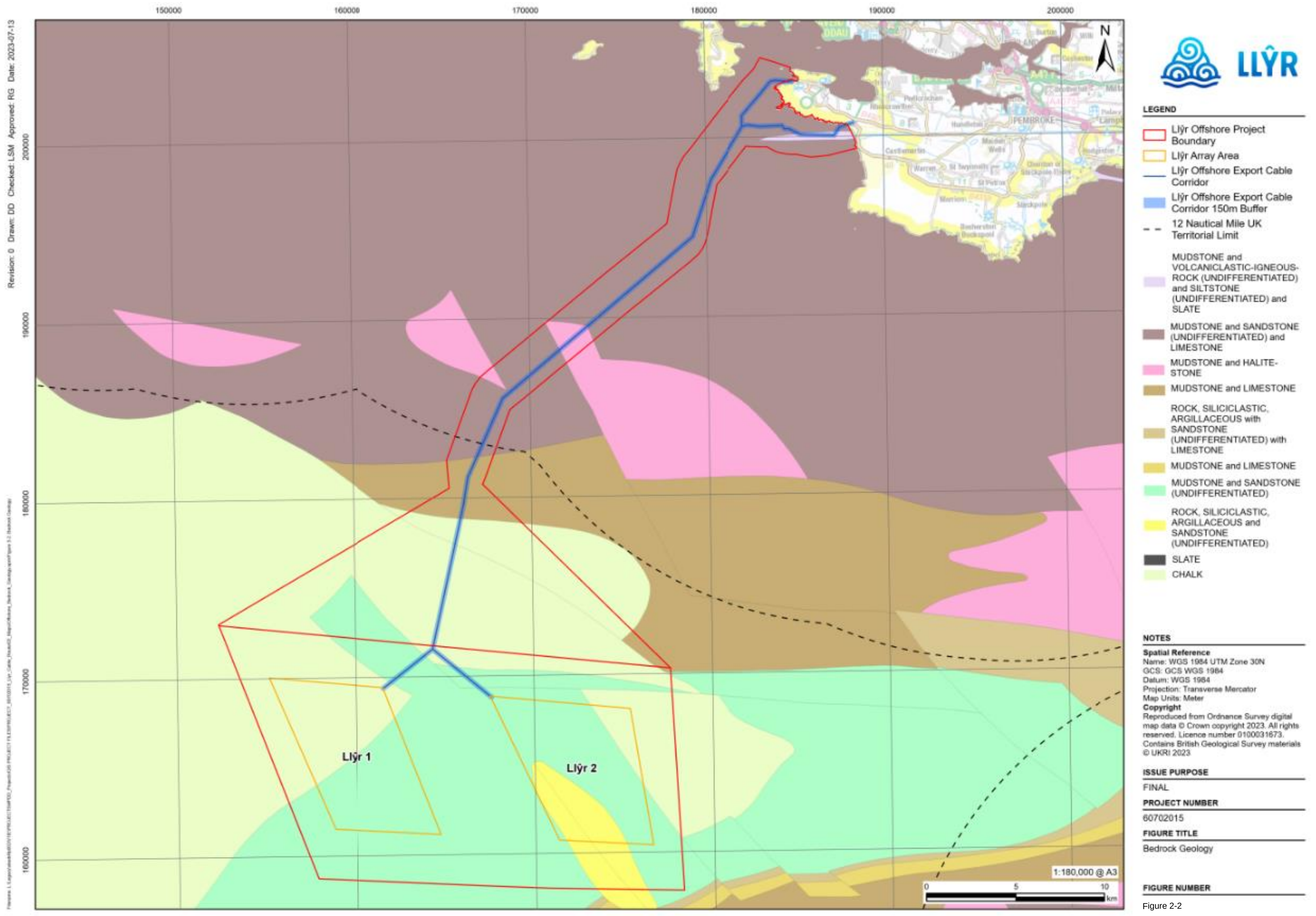

Figure 2-2. Bedrock Geology

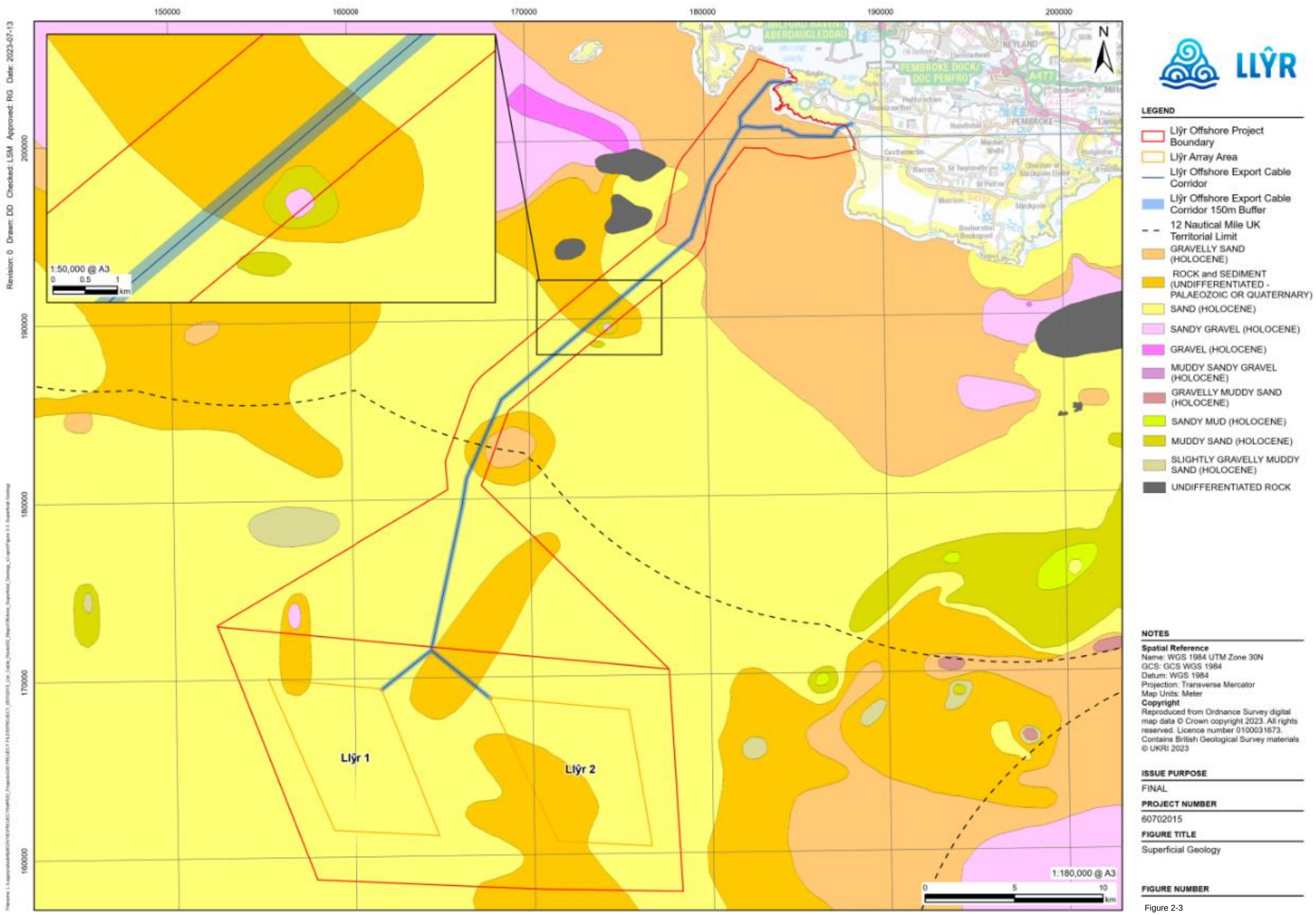

Figure 2-3. Superficial Geology

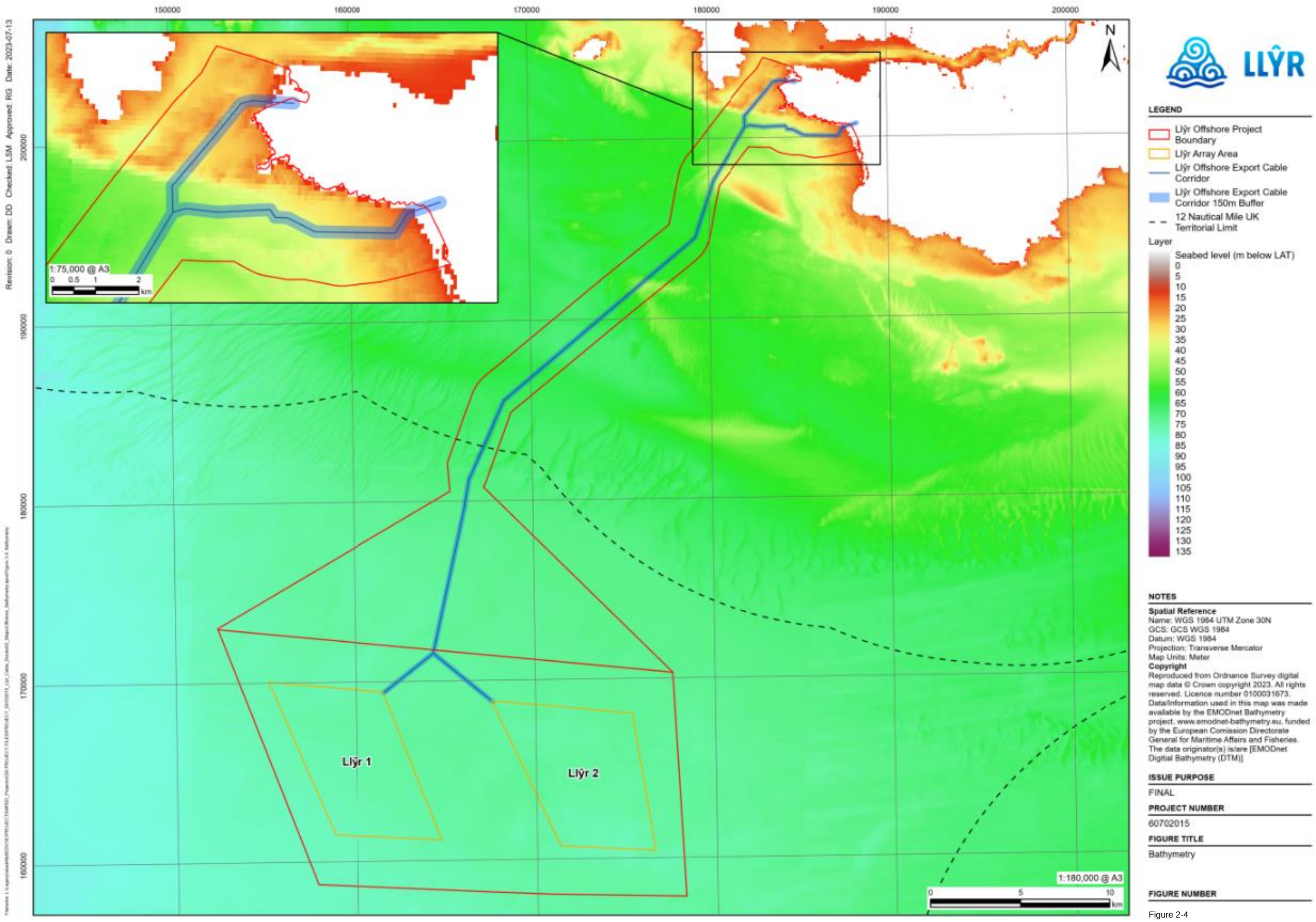

Figure 2-4. Bathymetry

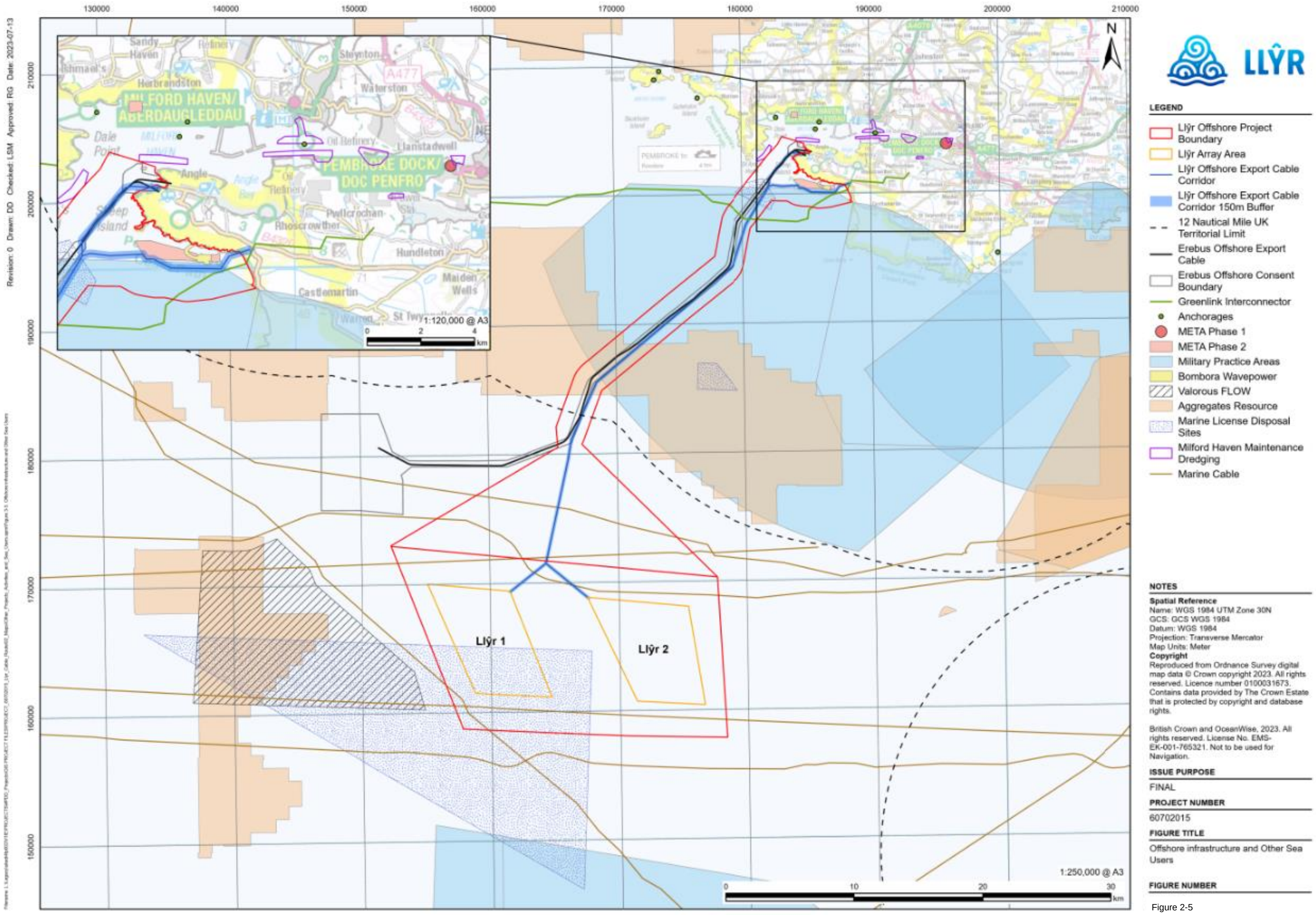

Figure 2-5. Offshore Infrastructure and Other Sea Users

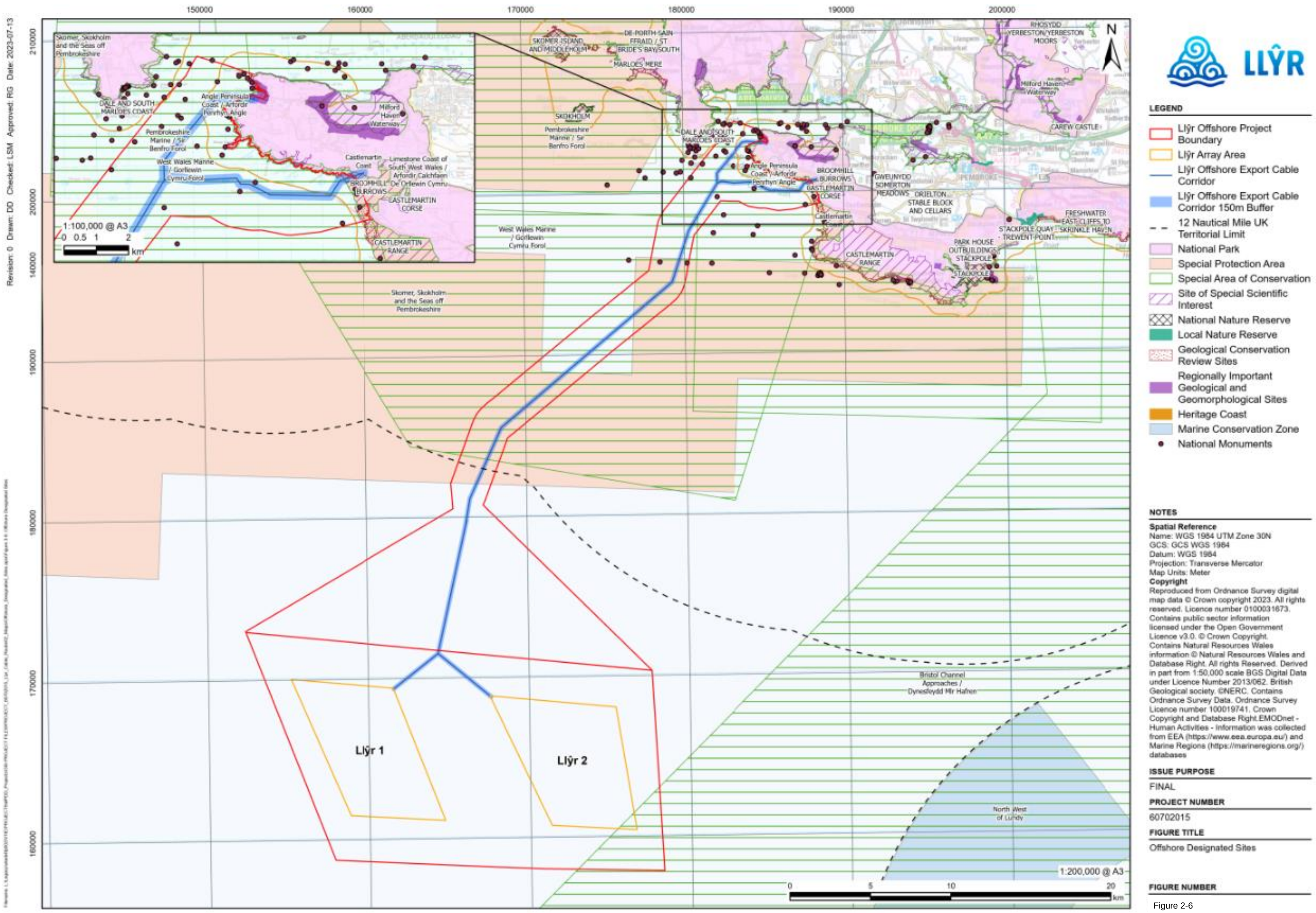

Figure 2-6. Offshore Designated Sites

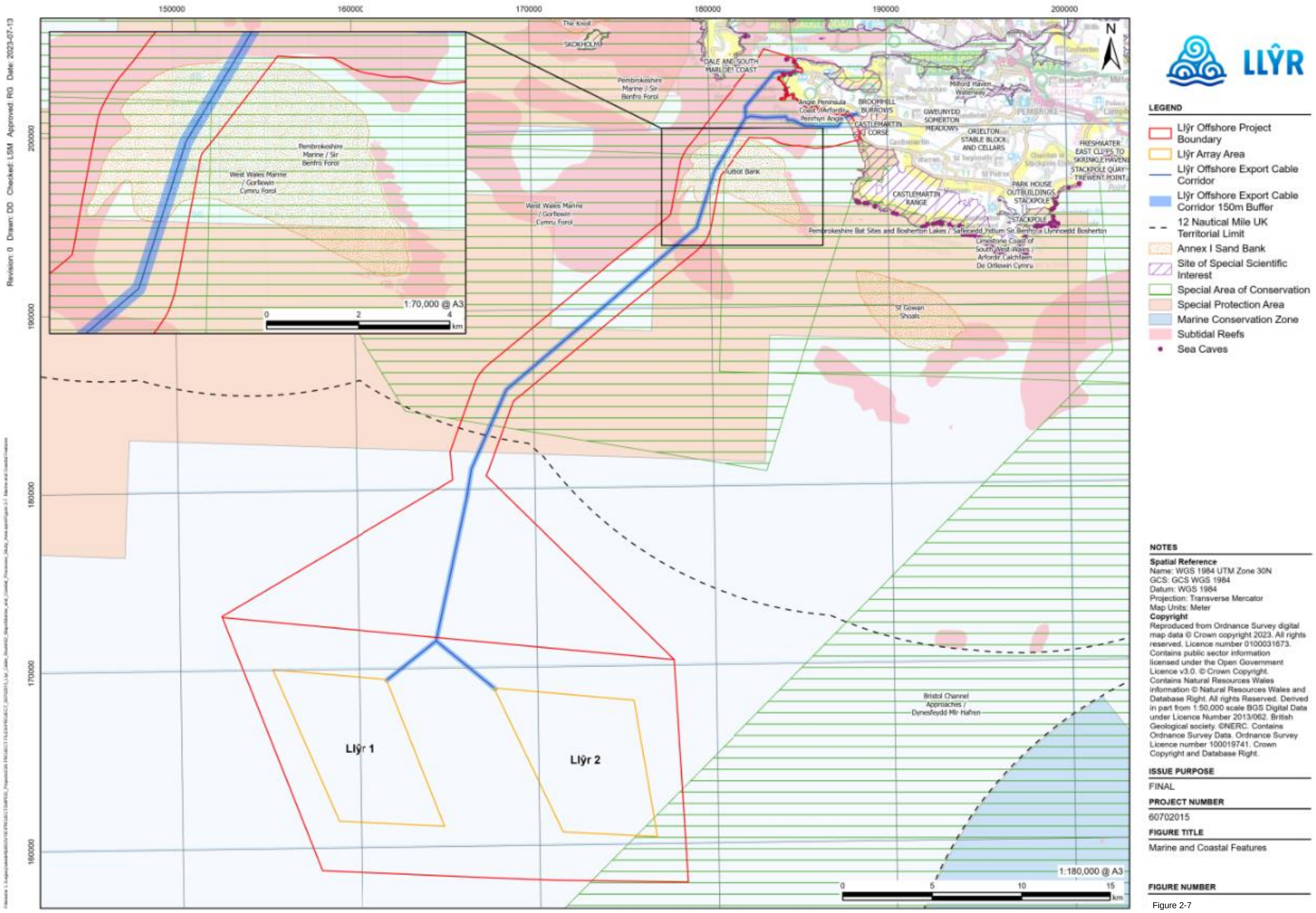

Figure 2-7. Marine and Coastal Features

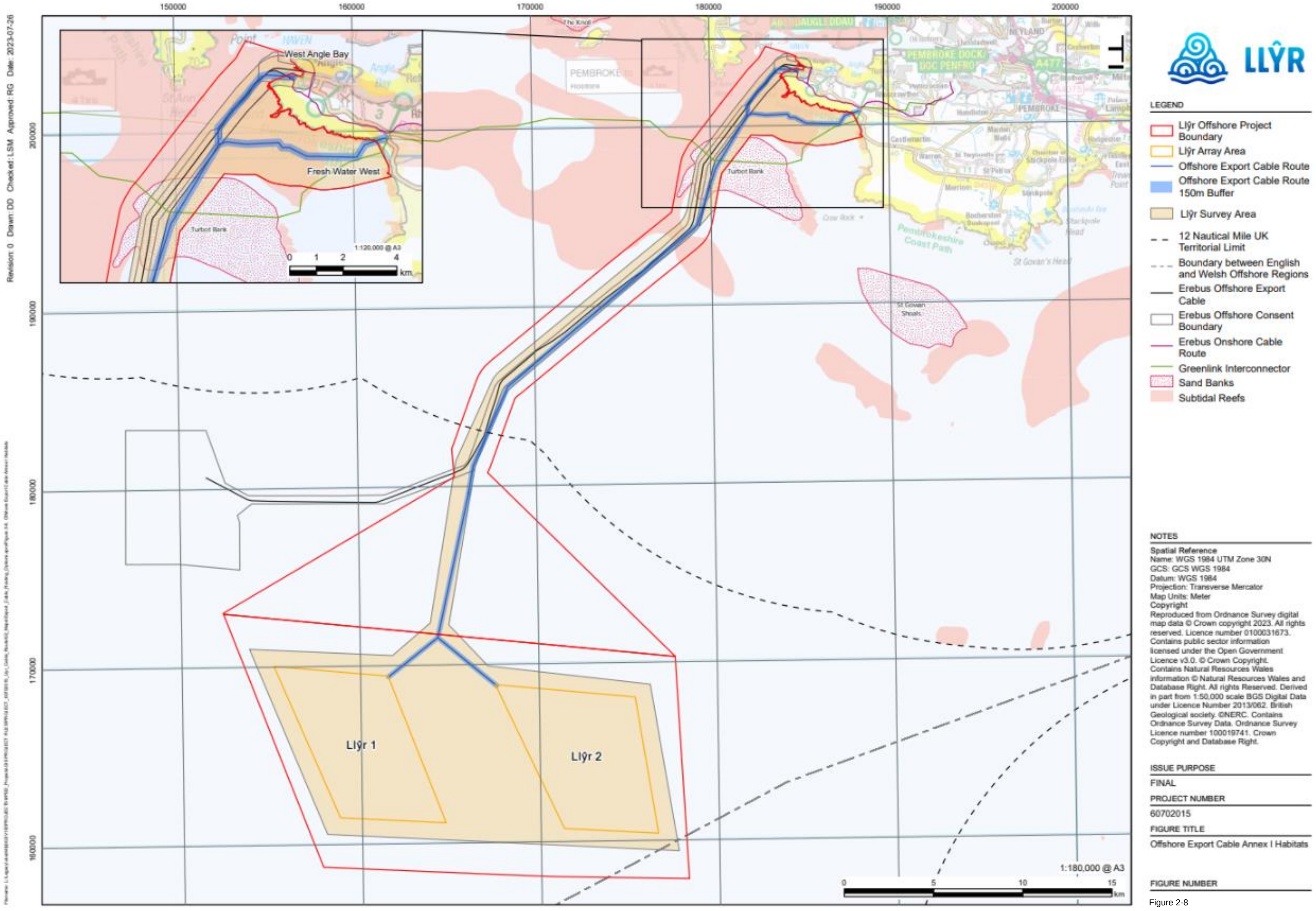

Figure 2-8. Offshore Export Cable Annex I Habitats

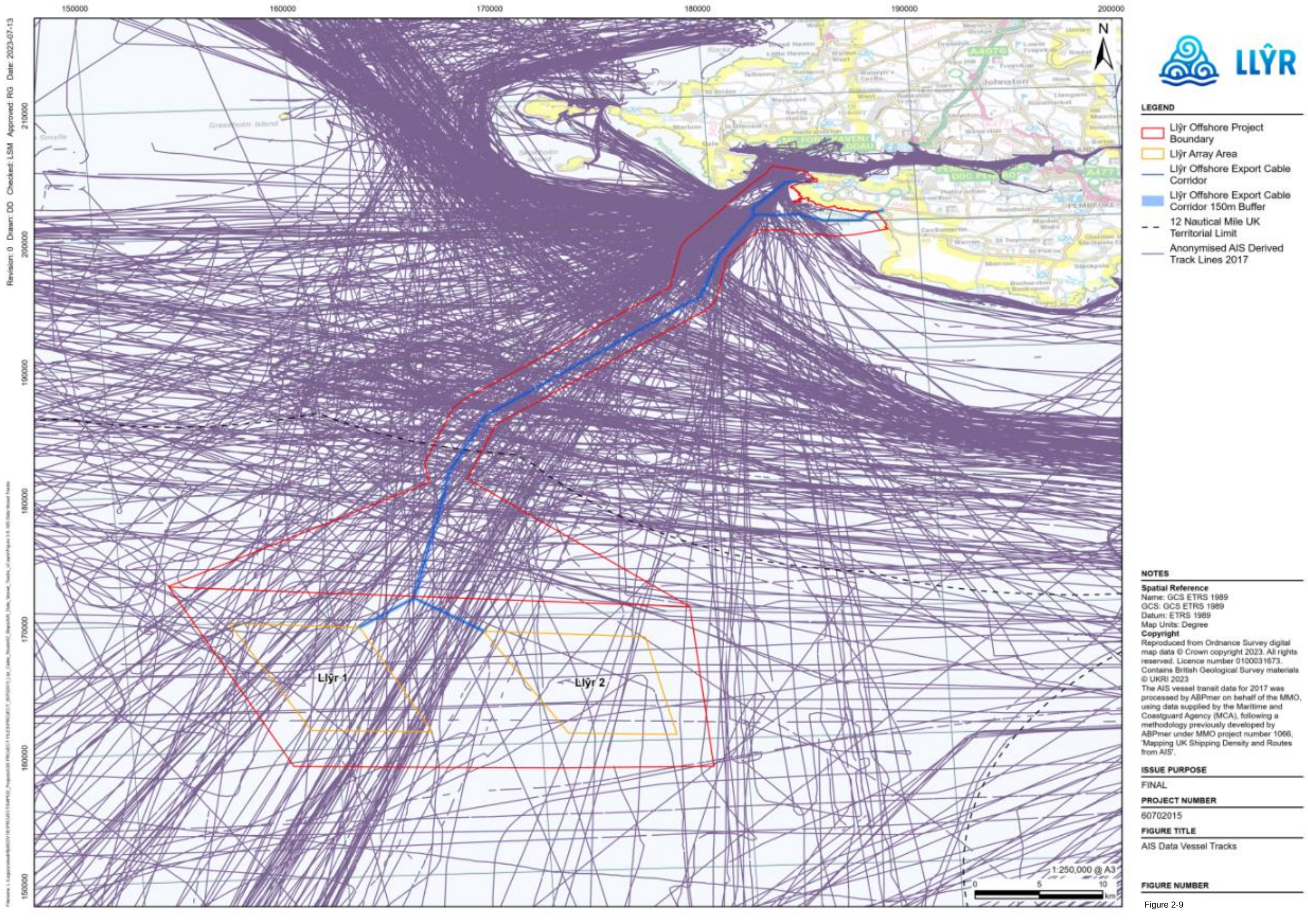

Figure 2-9. AIS Data Vessel Tracks

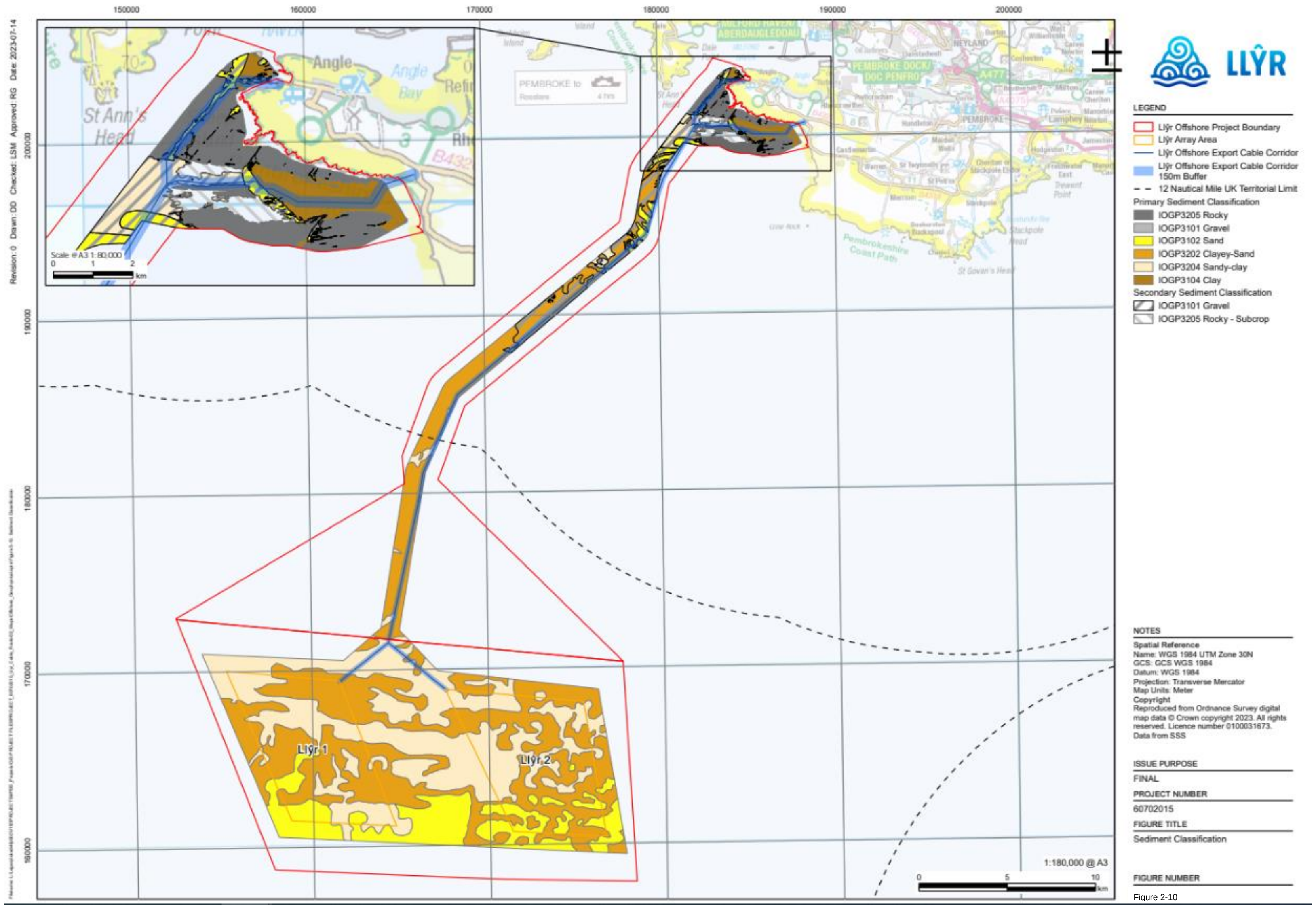

Figure 2-10. Seabed features and morphology part one

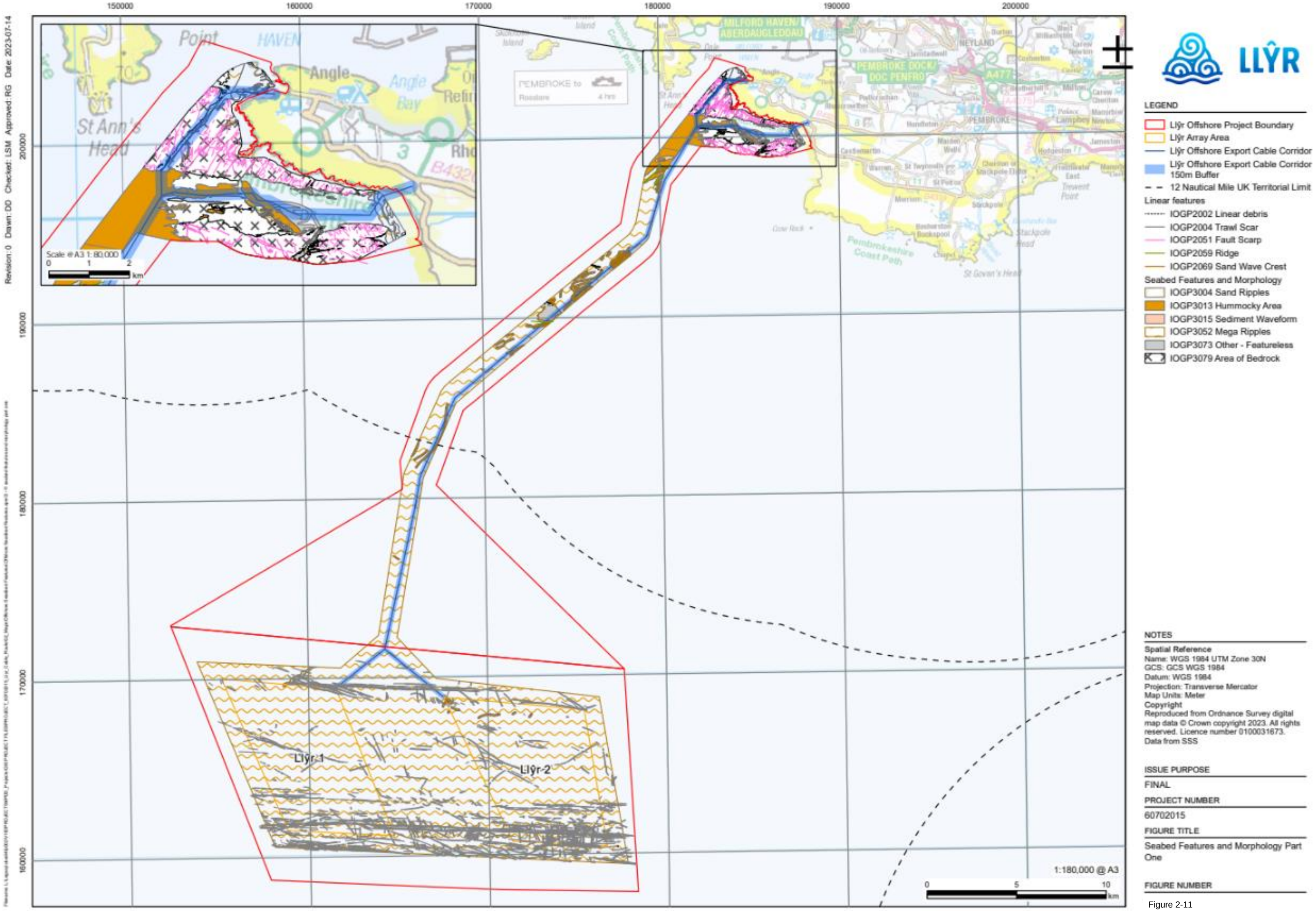

Figure 2-11. Seabed features and morphology part two

Table 2-1. Criteria for assessment of Project Llŷr Offshore Export Cable Corridor

Criterion	West Angle Bay	Freshwater West
Seabed geology and surface sediments, conditions and geohazards	The cable corridor passes over chalk, interbedded mudstone, and limestone near the array sites. Then the bedrock geology is mainly mudstone and sandstone from offshore into the Milford Haven Waterway and around the Angle Peninsula. Seabed sediments off the west coast of Wales are predominantly muddy sandy gravel. Substrates within the Milford Haven Waterway are characterised by hard substrates within central areas which are flanked by sheltered thick mudflats supplied by river accumulations. The unconsolidated sediment that characterises much of the inshore setting in the vicinity, is likely to be formed into bedform fields (RPS Energy, 2018. Marine Energy Test Area. Environmental Impact Assessment Scoping Report). The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) identified that the seabed levels range from -3.1 metres (above lowest astronomical tide (LAT)) to 72.8 metres, recorded in the southern section of the array area. The seabed morphology in the survey area is dominated by mobile sediment bedforms ranging from ripples to sand waves. The seabed profile generally follows the channel feature visible cutting through the band of rock dominating shore approaches within the nearshore section of the route at West Angle Bay. The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) identified the sediments and seabed features within the survey area. The nearshore area to West Angle Bay, close to the shore, the seabed is flat and featureless, with occasional patches of megarippled sediments. The megaripples become more frequent to south and west of the nearshore area. The most characteristic feature is the presence of bedrock exposures. There is a characteristic trough or gully feature, cutting through the exposed bedrock, generally along the centre of the study area corridor. The featureless areas at the shore approaches are most likely covered with mud. The megaripple sections coincide with the presence of Gravelly sand and the hummocky terrain is comprised of Gravelly Sandy mud.	The cable corridor passes over chalk, interbedded mudstone, and limestone near the array sites. Then the bedrock geology is mainly mudstone and sandstone from offshore into the Milford Haven Waterway and around the Angle Peninsula. Seabed sediments off the west coast of Wales are predominantly muddy sandy gravel. The seabed sediment inshore around the south Pembrokeshire coast is characterised by rocky reefs, shoals, and sandbanks, defined as 'hard substrate' (RPS Energy, 2018. Marine Energy Test Area. Environmental Impact Assessment Scoping Report). The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) identified that the seabed levels range from -2.9 metres (above LAT) to 72.8 metres, recorded in the southern section of the array area. The seabed morphology in the survey area is dominated by mobile sediment bedforms ranging from ripples to sand waves. With an extensive rock exposures creating a raised platform along the southern most edge of the nearshore survey area at Freshwater West. The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) identified the sediments and seabed features within the survey area. The nearshore area to Freshwater West is characterised by the presence of bedrock exposed on the seabed, mainly in two wide bands, one running along the coastline and second one running parallel to the southern boundary of the survey area. The middle section of the nearshore extension area exhibits mostly flat and featureless seabed morphology in the eastern part, and in the western part, mostly displaying hummocky character, with sections of shallow lying (sub-cropping) bedrock adjacent to the northern and southern bands of rock exposures. Narrow section between the eastern and western parts is covered by megarippled sediments and hummocky sections. The majority of the seabed sediments in the area is covered by exposed bedrock The featureless seabed in the east was interpreted as comprising mostly mud with localised presence of sand (megaripples). The middle section with megaripple features was recorded as consisting of Gravelly sand, while the hummocky seabed in the west is likely covered with Gravelly Muddy sand.

<table>
<tr><th>Criterion</th><th>West Angle Bay</th><th>Freshwater West</th></tr>
<tr><td></td><td>
Boulders are present throughout both nearshore sections, which are mostly classified as occasional boulder areas.
Beyond the West Angle Bay nearshore study are the following seabed sediments and features were identified.
<table>
<tr><th colspan="2">Sediment</th><th colspan="2">Seabed Feature</th></tr>
<tr><th>Class</th><th>% of the survey area</th><th>Class</th><th>% of the survey area</th></tr>
<tr><td>Sandy MUD</td><td>34.1%</td><td>Flat</td><td>0.5%</td></tr>
<tr><td>Gravelly Sandy MUD</td><td>0.7%</td><td>Hummocky</td><td>1.4%</td></tr>
<tr><td>Muddy SAND</td><td>45.8%</td><td>Megaripples</td><td>98.0%</td></tr>
<tr><td>Gravelly Muddy SAND</td><td>4.0%</td><td>Sand Waves</td><td>1.4%</td></tr>
<tr><td>SAND</td><td>14.9%</td><td>Long Wavelength Sand Waves</td><td>0.1%</td></tr>
<tr><td>Gravelly SAND</td><td>0.5%</td><td>Subcrop</td><td>>0.1%</td></tr>
<tr><td>Subcrop</td><td>>0.1%</td><td>Rocky</td><td>>0.1%</td></tr>
<tr><td>Rocky</td><td>>0.1%</td><td></td><td></td></tr>
</table>
In addition, the survey identified the following in total between the array area and West Angle Bay: 429 isolated boulders, 77 debris, 1 wreck, and 6 trawl scars. Where possible the route will need to be refined further to avoid sensitive seabed features, such as sand waves and boulder fields, as part of the next stage. A cable burial assessment will be required.
</td><td>
Boulders are present throughout both nearshore sections, which are mostly classified as occasional boulder areas. Localised patches of numerous boulders were also mapped, mostly in the west Freshwater West study area.
Beyond the Freshwater West nearshore study are the following seabed sediments and features were identified.
<table>
<tr><th colspan="2">Sediment</th><th colspan="2">Seabed Feature</th></tr>
<tr><th>Class</th><th>% of the survey area</th><th>Class</th><th>% of the survey area</th></tr>
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<tr><td>Rocky</td><td>>0.1%</td><td></td><td></td></tr>
</table>
In addition, the survey identified the following between the array area and Freshwater West: 570 isolated boulders, 35 debris, 4 wrecks, and 6 trawl scars in the offshore survey area. Where possible the route will need to be refined further to avoid sensitive seabed features, such as sand waves and boulder fields, as part of the next stage. A cable burial assessment will be required.
</td></tr>
</table>

Criterion	West Angle Bay	Freshwater West
Pipelines and Cables, including Project Erebus and Greenlink	At this time, it is known that the offshore cable corridor will cross four subsea cables, namely the SOLAS cable (Vodafone), Gemini North – Seg 2, TATA Atlantic North, and the Greenlink Interconnector. The crossing of Greenlink will be around the Turbot Bank area and the other three cables are immediately north of the array areas. The Project Llŷr offshore cable corridor also overlaps with the Project Erebus offshore cable corridor, there needs to be a consideration of an acceptable separation distance. Project Erebus has two potential landfall sites at West Angle Bay, once BGW has selected one of these two sites, then Project Llŷr could remain within the Project Erebus cable corridor by adopting the other site. The infrastructure for both Projects would need to be adequately separated (120 metres) and, ideally, any cable crossing points avoided.	At this time, it is known that the offshore cable corridor will cross four subsea cables, namely the SOLAS cable (Vodafone), Gemini North – Seg 2, TATA Atlantic North, and the Greenlink Interconnector. The crossing of Greenlink will be around the Turbot Bank area and the other three cables are immediately north of the array areas. . CymCap modelling has indicated that 150 m is the minimum separation between Project Erebus and Project Llyr. The exact location of the Project Erebus cable within their corridor is not yet confirmed, however ,it is noted that the Project Llŷr offshore cable corridor overlaps with the Project Erebus offshore cable corridor. It is recommended that the offshore survey area is increased by 750 m to the east, based on industry best practise, to provide certainty that the an independent offshore route can be re-routed to remain at an acceptable separation distance for Project Erebus, while avoiding other constraints. Furthermore, Greenlink have a landfall at Freshwater West, this infrastructure will already be in place prior to Project Llŷr's construction but will require an adequate separation. Further electrical calculations are required to determine this distance.
Renewable energy sites e.g. windfarms and wave energy	The corridor to West Angle Bay would avoid the Bombora Wavepower and Marine Energy Test Area (META) lease areas. The Project Erebus and Project Valorous wind farms lease areas are to the west of the offshore scoping boundary. Project Erebus is also considering two landfall sites at West Angle Bay.	The offshore corridor to Freshwater West would pass along the edge of the lease areas for Bombora Wavepower and META, 10 metre separation distance at the closest point, consultation will be required. The Project Erebus and Project Valorous wind farms lease areas are to the west of the offshore scoping boundary. Project Valorous has submitted a Scoping Report which also considers landfall at Freshwater West. No further details are available at present
Ports and anchorage areas	The offshore corridor to West Angle Bay would cross over the entrance to the Port of Milford Haven. Milford Haven also has a marina, which has a Royal Yachting Association (RYA) training centre. An additional RYA training centre is located in Gelliswick, to the east of Milford Haven Port, whilst Pembroke Dock has a RYA yacht club. There is a formal anchorage in Milford Haven, regularly used by oil and chemical tankers, as well as recreational vessels. There are also three informal anchorages located to the west of Milford Haven entrance. While the route avoids known anchorage areas, there is still a risk from emergency anchoring.	The offshore corridor to Freshwater West does not cross over with the entrance to the Port of Milford Haven or any formal anchorage points within Milford Haven. While the route avoids known anchorage areas, there is still a risk from emergency anchoring. Although, less risk than West Angle Bay.

Criterion	West Angle Bay	Freshwater West
Shipping	Density of commercial vessels (as measured by automated identification systems [AIS] track lines for 2017) is high across the offshore corridor, particularly concentrated transiting to and from Milford Haven, and in and out of the Celtic Sea via a shipping lane. An offshore cable corridor for landfall sites at West Angle Bay will encroach into the shipping lane at the entrance to Milford Haven During installation / maintenance, shipping vessels may need to slightly alter their course to avoid any vessels that may be restricted in its ability to manoeuvre, to allow safe passage of the cable installation vessel.	Density of commercial vessels (as measured by automated identification systems [AIS] track lines for 2017) is high across the offshore corridor, particularly concentrated transiting to and from Milford Haven, and in and out of the Celtic Sea via a shipping lane. An offshore cable corridor for landfall sites at Freshwater West will encroach into the approach to Milford Haven but not the shipping lane at the entrance of the port.
Commercial fishing e.g. fish farms	In Welsh waters, demersal and shellfish are the key target species groups. With the exception of larger vessels working out of Milford Haven, most fishing off the southwest coast of Wales occurs close inshore. There is an aquaculture resource area located of the south coast of the Angle Peninsula, the offshore export cable will cross this. However, this is not an active fish farm site (ABPmer (2015): DataMap Wales). The Draft Commercial Fisheries Baseline Report by Poseidon Aquatic Resource Management Ltd (Llŷr Floating Offshore Wind Project, Technical Report, Commercial Fisheries Baseline, 2023) identified that the proposed Project array areas are located within International Council for the Explorations of the Sea (ICES) rectangle 31E4 and the majority of the offshore Export Cable Corridor is within rectangle 32E4. Average annual landings value in ICES rectangle 32E4 from 2016 to 2021 were £2.3 million whilst the equivalent value in ICES rectangle 31E4 was £405,000. The key species landed from ICES rectangle 31E4 (inclusive of the offshore array areas) are brown crabs (*Cancer pagurus)*, lobsters (*Homarus gammarus)* and sole (*Solea solea)*, and from ICES rectangle 32E4 (inclusive of the majority of the offshore cable route corridor) are lobsters, whelks (*Buccinum undatum)*, brown crabs, and spider crabs (*Maja brachydactyla)*. Other species being fished include, but are not exclusive to, bass (*Dicentrarchus labrax)*, king scallop (*Pecten maximus)*, plaice (*Pleuronectes platessa)*, whiting (*Merlangius merlangus)*, haddock (*Melanogrammus aeglefinus),* thornback rays (*Raja clavate)*, blonde rays (*Raja brachyura*), and Nephrops (*Nephrops norvegicus)*.	In Welsh waters, demersal and shellfish are the key target species groups. With the exception of larger vessels working out of Milford Haven, most fishing off the southwest coast of Wales occurs close inshore. There is an aquaculture resource area located of the south coast of the Angle Peninsular, the offshore export cable will cross this. However, this is not an active fish farm site (ABPmer (2015): DataMap Wales). The Draft Commercial Fisheries Baseline Report by Poseidon Aquatic Resource Management Ltd (Llŷr Floating Offshore Wind Project, Technical Report, Commercial Fisheries Baseline, 2023) identified that the proposed Project array areas are located within ICES rectangle 31E4 and the majority of the offshore Export Cable Corridor is within rectangle 32E4. Average annual landings value in ICES rectangle 32E4 from 2016 to 2021 were £2.3 million whilst the equivalent value in ICES rectangle 31E4 was £405,000. The key species landed from ICES rectangle 31E4 (inclusive of the offshore array areas) are brown crabs, lobsters and sole, and from ICES rectangle 32E4 (inclusive of the majority of the offshore cable route corridor) are lobsters, whelks, brown crabs, and spider crabs. Other species being fished include, but are not exclusive to, bass, king scallop, plaice, whiting, haddock, thornback rays, blonde rays, and Nephrops The Draft Commercial Fisheries Baseline Report by Poseidon Aquatic Resource Management Ltd noted that aerial surveillance records indicate that in offshore ICES rectangle 31E4, the majority of observations were of beam trawlers, with smaller numbers of observations of potting vessels and scallop dredgers. In inshore ICES rectangle 32E4, surveillance observations were, on the whole, less in number than those recorded in 31E4. Observations in 31E4 were comprised entirely of trawlers and potting vessels.

Criterion	West Angle Bay	Freshwater West
	The Draft Commercial Fisheries Baseline Report by Poseidon Aquatic Resource Management Ltd noted that aerial surveillance records indicate that in offshore ICES rectangle 31E4, the majority of observations were of beam trawlers, with smaller numbers of observations of potting vessels and scallop dredgers. In inshore ICES rectangle 32E4, surveillance observations were, on the whole, less in number than those recorded in 31E4. Observations in 31E4 were comprised entirely of trawlers and potting vessels.	
Cultural heritage e.g. wrecks	National monuments, including wrecks have been identified in the scoping boundary. Constraints mapping of National monuments data identified two potential wrecks on the approach to West Angle Bay. One is an unnamed modern wreck of a barge lying with its keel orientated 070/250 degrees[1]. The wreck is intact and sitting upright on the seabed. The wreck's reported length is 30-36 metres, width 8-10 metres, and it has a height of 2.25 metres above the general level of the seabed. The other is a Post Medieval wreck named Emily, a wooden sailing vessel[2]. Archaeological remains associated with the loss of this vessel are not confirmed as present at this location but may be in the vicinity. The offshore geophysical survey identified two wrecks within the study area: 'Christian Borum' wreck in the array area and an unidentified wreck north of the array area.	National monuments, including wrecks have been identified in the scoping boundary. Constraints mapping of National monuments data identified five potential wrecks on the approach to Freshwater West. One is the same unnamed modern wreck as West Angle Bay. Another is a Post Medieval wreck of one LCG No 15; landing craft LCG No 15 were landing craft of 627 tonnes, which were to be used in the invasion of Sicily[3]. This wreck is reported to lie upside down. There is also a modern wreck, unnamed, which lies orientated north-south with the bows to the north and has a length of 70 metres and width of 10 metres[4]. The wreck stands 3 metres above the general level of the seabed. A Post Medieval wreck, unnamed, was uncovered on Freshwater West beach[5]. The upside down remains of a wooden vessel comprising a length of keel, outer planking fastened with iron pins, together with main and filling frames were uncovered on the beach. The beach had dropped and scoured around the remains to expose some 15.5 metres x 3.4 metres of the vessel. Some 20 metres to the south, an additional piece of timber and concretions were also recorded. There is also another Post Medieval wreck, named Gram Para[6]. This record comprises a documentary reference to a shipping casualty, which has been assigned to the maritime named location 'Freshwater West', pending more information, which may allow a more precise location for the loss to be assigned. The offshore geophysical survey identified five wrecks within the study area: potentially 'Highland Home' in the Freshwater West nearshore survey area, LCG15 mentioned previously, and an unidentified wreck in the nearshore area to Freshwater West. 'Christian Borum' in the array area and an unidentified wreck north of the array area were also identified.

[1] https://coflein.gov.uk/en/site/240877/
[2] https://coflein.gov.uk/en/site/273321/
[3] https://coflein.gov.uk/en/site/273231/
[4] https://coflein.gov.uk/en/site/240879/
[5] https://coflein.gov.uk/en/site/420445/
[6] https://coflein.gov.uk/en/site/518276/

Criterion	West Angle Bay	Freshwater West
Military areas	Offshore cable corridor would pass through the Castlemartin Range Sea Danger Area. The programme for installation will need to consider periods when the firing range may be in use. Consultation with the MOD is ongoing to establish the presence of no go areas and discuss any potential use conflicts. In addition to routine firing operations at Castlemartin Range, radar, communication, and surveillance operations also occur here, as well as occasional Royal Navy operations, including low flying exercises at times.	An offshore cable corridor for landfall sites at Freshwater West is likely to encroach upon the Castlemartin Range Sea Danger Area within Freshwater West bay. An offshore cable corridor leading to the southern landfall site is more likely to extend into the danger area, within the bay, when compared with an offshore cable corridor leading to the north landfall site. Installation will need to be carried out at times of the year when the firing range is not in use. Consultation with the MOD to establish the presence of no go areas and discuss any potential use conflicts. In addition to routine firing operations at Castlemartin Range, radar, communication, and surveillance operations also occur here, as well as occasional Royal Navy operations, including low flying exercises at times.
Dumped munitions and UXO	The corridor will need to avoid dropped objects, marine debris and any potential UXO. The offshore geophysical survey identified 77 items of debris in the offshore survey area. A survey will need to be undertaken to find any potential UXO or other munitions along the cable corridor, especially in the nearshore area to West Angle Bay prior to installation. Stakeholder consultation will be required with the MOD.	The corridor will need to avoid dropped objects, marine debris and any potential UXO. The offshore geophysical survey identified 35 items of debris in the offshore survey area. A survey will need to be undertaken to find any potential UXO or other munitions along the cable corridor, especially in the nearshore area to Freshwater West prior to installation. Stakeholder consultation will be required with the MOD.
Aggregate extraction sites	The offshore corridor crosses an aggregates resource area previously identified by TCE but does not cross over a site that has a production agreement, active site or licenses pending.	The offshore corridor crosses an aggregates resource area previously identified by TCE but does not cross over a site that has a production agreement, active site or licenses pending.
Disposal areas and dredging	The offshore export cable corridor intersects the footprint of the Milford Haven historic dredge disposal site (LU170), which was used until 1994. The corridor would also pass close to the closed St Ann's Head Offshore Disposal Site (LU180) for both landfalls. Although details are not available of contamination levels in material disposed at this site, the site was used for spoil dredged from Milford Haven Port and would be expected to contain contaminants typically associated with shipping and transport hubs, such as Tributyltin (TBT), hydrocarbons, and heavy and trace metals. An assessment will be required of the potential effect to water quality and marine ecology from installing the offshore export cable through the historic disposal ground. The licensing of disposal sites is regulated through licensing and consents by Natural Resource Wales (NRW), consultation is required.	The offshore export cable corridor intersects the footprint of the Milford Haven historic dredge disposal site (LU170), which was used until 1994. The corridor would also pass close to the closed St Ann's Head Offshore Disposal Site (LU180) for both landfalls. Although details are not available of contamination levels in material disposed at this site, the site was used for spoil dredged from Milford Haven Port and would be expected to contain contaminants typically associated with shipping and transport hubs, such as TBT, hydrocarbons, and heavy and trace metals. An assessment will be required of the potential effect to water quality and marine ecology from installing the offshore export cable through the historic disposal ground. The licensing of disposal sites is regulated through licensing and consents by NRW, consultation is required. Dredging areas have been identified, these are within the Milford Haven Waterway and do not intersect with the cable corridor.

<table>
<tr><th>Criterion</th><th>West Angle Bay</th><th>Freshwater West</th></tr>
<tr><td></td><td>Dredging areas have been identified, these are within the Milford Haven Waterway and do not intersect with the cable corridor.</td><td></td></tr>
<tr><td>Protected sites e.g., SAC, SPA, SSSIs, Ramsar sites, MCZ</td><td>The landfall location and sections of the offshore cable corridor lies within two statutory ecological designations (Pembrokeshire Marine / Sir Benfro Forol SAC and Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI) and is in close proximity to a third (West Wales Marine / Gorllewin Cymru Forol SAC).
• Pembrokeshire Marine / Sir Benfro Forol SAC[7]. This site is designated for the protection of certain habitats and species. Of relevance to the project are the presence of the habitat 'Reef' and species grey seal (Halichoerus grypus) and otter (Lutra lutra).
• Angle Peninsula Coast / Arfordir Penrhyn Angle SSSI[8] supports a small breeding population and roosting areas for a significant proportion of the South Pembrokeshire non-breeding population of chough (Pyrrhocorax pyrrhocorax).
• West Wales Marine / Gorllewin Cymru Forol SAC[9]. This site has been designated to protect harbour porpoise (Phocoena phocoena).
The onshore cable would pass in close proximity to the Limestone Coast of South West Wales SAC, Castlemartin Coast SPA, and Broomhill Burrows SSSI, which.
• Limestone Coast of South West Wales/ Arfordir Calchfaen de Orllewin Cymru SAC[10]. This site is designated for the protection of a range of terrestrial habitats and plant species.
• Castlemartin Coast SPA[11]. Designated to protect breeding and overwintering populations of chough.
• Broomhill Burrows SSSI[12] is one of Pembrokeshire's largest dune systems with the most extensive and most diverse dune slack vegetation.</td><td>Whilst the landfall sites are located outside of the protected areas at Freshwater West, the cable routes offshore and onshore would still pass through two SACs (the Pembrokeshire Marine / Sir Benfro Forol SAC and Limestone Coast of South West Wales / Arfordir Calchfaen De Orllewin Cymru SACs), an SPA (Castlemartin Coast), and the particularly sensitive dune system of Broomhill Burrows SSSI.
• Pembrokeshire Marine / Sir Benfro Forol SAC. This site is designated for the protection of certain habitats and species. Of relevance to the project are the presence of the habitat 'Reef' and species grey seal and otter.
• Limestone Coast of South West Wales/ Arfordir Calchfaen de Orllewin Cymru SAC. This site is designated for the protection of a range of terrestrial habitats and plant species.
• Castlemartin Coast SPA. Designated to protect breeding and overwintering populations of chough.
• Broomhill Burrows SSSI is one of Pembrokeshire's largest dune systems with the most extensive and most diverse dune slack vegetation.
The offshore cable corridor does not interact with the Milford Haven Waterway SSSI or the Skomer MCZ.</td></tr>
</table>

[7] https://sac.jncc.gov.uk/site/UK0013116
[8] https://naturalresources.wales/media/655205/SSSI_0923_Citation_EN0017f83.pdf
[9] https://sac.jncc.gov.uk/site/UK0030397
[10] https://sac.jncc.gov.uk/site/UK0014787
[11] https://jncc.gov.uk/jncc-assets/SPA-N2K/UK9014061.pdf
[12] https://naturalresources.wales/media/660298/SSSI_1136_Citation_EN0015d06.pdf

Criterion	West Angle Bay	Freshwater West
	The offshore cable corridor does not interact with the Milford Haven Waterway SSSI or the Skomer MCZ[13].	
Annex I Habitats	The proposed corridor and landfall sites at West Angle Bay are within the Pembrokeshire Marine / Sir Benfro Forol SAC designated for a range of broadscale Annex I habitats: • Estuaries[14]; • Large shallow inlets and bays[15]; • Reefs[16]; • Sandbanks which are slightly covered by sea water all the time[17]; • Mudflats and sandflats not covered by seawater at low tide[18]; • Coastal lagoon[19]; • Atlantic salt meadows[20]; and • Submerged or partially submerged sea caves[21]. The offshore cable corridor would pass through a sandbank, Turbot Bank, and there is a risk of interaction/impact on the subtidal and intertidal reef features that are a key component of the SAC. It is likely that a cable burial risk assessment (CBRA) will need to minimise and mitigate the need for cable protection in this area, as the introduction of hard materials, such as cable protection, to this sandbank may not be acceptable by NRW, whilst still reducing the risk of future cable exposure, requiring additional maintenance work or cable protection. Reducing the use of cable protection when crossing this feature will minimise the	The proposed corridor and landfall sites at Freshwater West are within the Pembrokeshire Marine / Sir Benfro Forol SAC designated for a range of broadscale Annex I habitats: • Estuaries; • Large shallow inlets and bays; • Reefs; • Sandbanks which are slightly covered by sea water all the time; • Mudflats and sandflats not covered by seawater at low tide; • Coastal lagoon; • Atlantic salt meadows; and • Submerged or partially submerged sea caves. The offshore cable corridor would pass through a sandbank, Turbot Bank, and there is a risk of interaction/impact on the subtidal and intertidal reef features that are a key component of the SAC. It is likely that a CBRA will need to minimise and mitigate the need for cable protection in this area, as the introduction of hard materials, such as cable protection, to this sandbank may not be acceptable by NRW, whilst still reducing the risk of future cable exposure, requiring additional maintenance work or cable protection. Reducing the use of cable protection when crossing this feature will minimise the introduction of new species to the Annex I habitat and changes in suspended sediment/smothering. However, a Marine INNS Strategy may be required as well as commitments by the construction vessel and / or contractors.

[13] https://naturalresources.wales/guidance-and-advice/environmental-topics/wildlife-and-biodiversity/protected-areas-of-land-and-seas/skomer-marine-conservation-zone/?lang=en
[14] https://sac.jncc.gov.uk/habitat/H1130/
[15] https://sac.jncc.gov.uk/habitat/H1160/
[16] https://sac.jncc.gov.uk/habitat/H1170/
[17] https://sac.jncc.gov.uk/habitat/H1110/
[18] https://sac.jncc.gov.uk/habitat/H1140/
[19] https://sac.jncc.gov.uk/habitat/H1150 /
[20] https://sac.jncc.gov.uk/habitat/H1330/
[21] https://sac.jncc.gov.uk/habitat/H8330/

Criterion	West Angle Bay	Freshwater West
	introduction of new species to the Annex I habitat and changes in suspended sediment/smothering. However, a Marine Invasive Non-Native Species (INNS) Strategy may be required as well as commitments by the construction vessel and / or contractors. Construction activities associated with the route preparation and array and cable installation phases may include cable burial by ploughing, trenching, or excavating, and vessel and turbine anchor placement. These activities can result in temporary physical disturbance to and/or loss of intertidal and subtidal benthic habitats and species. Construction activities associated with route preparation (e.g. clearance) and cable installation can also lead to direct physical disturbance (i.e. reworking) of substrate which may lead to disturbance and/or loss of benthic habitats and species within the footprint and immediate vicinity of the intertidal and subtidal works. Furthermore, cable installation may require protection, such as rock placement, concrete mattresses, or grout bags, at some locations. Introduction of hard substrate would replace otherwise soft substrates, leading to permanent loss of these habitats and species. Further discussion available in Section 3.	Construction activities associated with the route preparation and array and cable installation phases may include cable burial by ploughing, trenching, or excavating, and vessel and turbine anchor placement. These activities can result in temporary physical disturbance to and/or loss of intertidal and subtidal benthic habitats and species. Construction activities associated with route preparation (e.g. clearance) and cable installation can also lead to direct physical disturbance (i.e. reworking) of substrate which may lead to disturbance and/or loss of benthic habitats and species within the footprint and immediate vicinity of the intertidal and subtidal works. Furthermore, cable installation may require protection, such as rock placement, concrete mattresses, or grout bags, at some locations. Introduction of hard substrate would replace otherwise soft substrates, leading to permanent loss of these habitats and species. Further discussion available in Section 3.
Benthic Habitat	The intertidal habitat surrounding Angle Peninsula, has been identified as comprising predominantly 'littoral rock and other hard substrata' (European Nature Information System (EUNIS) A1), from online mapping data. This rocky shore consisted of low to high energy littoral rock, depending on the vertical location on the shore and the varying exposure. Biotopes consisting of fucoids (*Fucus* sp.), mussels and barnacles were common, particularly '*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock' (EUNIS A1.2141), as well as '*Himanthalia elongata* and red seaweeds on exposed lower eulittoral rock' (EUNIS A1.123). This habitat can be found within West Angle Bay. The intertidal habitat within the centre of West Angle Bay are areas of fine, clean, littoral sand, identified as the biotope 'polychaetes in littoral fine sand' (EUNIS A2.231) and '*Eurydice pulchra* in littoral mobile sand' (EUNIS A2.2232). On the upper littoral fringe of West Angle Bay are small areas of 'barren littoral shingle' (EUNIS A2.111).	The intertidal habitat surrounding Angle Peninsula, has been identified as comprising predominantly 'littoral rock and other hard substrata' (EUNIS A1), from online mapping data. This rocky shore consisted of low to high energy littoral rock, depending on the vertical location on the shore and the varying exposure. Biotopes consisting of fucoids (*Fucus* sp.), mussels and barnacles were common, particularly '*Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock' (EUNIS A1.2141), as well as '*Himanthalia elongata* and red seaweeds on exposed lower eulittoral rock' (EUNIS A1.123). This habitat can be found within Freshwater West. The intertidal habitat within the centre of Freshwater West (south) are areas of fine, clean, littoral sand, identified as the biotope 'polychaetes in littoral fine sand' (EUNIS A2.231) and '*Eurydice pulchra* in littoral mobile sand' (EUNIS A2.2232). The habitats in the Offshore Cable Scoping Boundary change along the cable corridor transitioning to 'circalittoral fine sand'/ 'circalittoral muddy sand' (EUNIS A5.25/ A5.26) to then 'circalittoral coarse sediment' (EUNIS A5.14). The subtidal habitat surrounding Angle Peninsula

<table>
<tr><th>Criterion</th><th>West Angle Bay</th><th>Freshwater West</th></tr>
<tr><td></td><td>The habitats in the Offshore Cable Scoping Boundary change along the cable corridor transitioning to ‘circalittoral fine sand’/ ‘circalittoral muddy sand’ (EUNIS A5.25/ A5.26) to then ‘circalittoral coarse sediment’ (EUNIS A5.14). The latter habitat extends up to the intertidal within West Angle Bay. The subtidal habitat surrounding Angle Peninsula also comprised extensive areas of high energy infralittoral and circalittoral rock (EUNIS A3.1/ A4.1), which can be found in West Angle Bay. These habitats (with the exception of high energy infralittoral and circalittoral rock (EUNIS A3.1/ A4.1) which are representative of the Annex I habitat, namely reefs.
The preliminary habitat assessment (Llŷr Floating Offshore Windfarm, Benthic Characterisation Survey 2022: Preliminary Habitat Assessment Report. REF: OEL_NSELLY0122_HA) showed that the offshore cable corridor would cross over the following habitats:
• A4.13: Mixed faunal turf communities on circalittoral rock
• A5.35: Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud;
• A5.26: Circalittoral muddy sand;
• A5.25: Circalittoral fine sand; and
• A5.44: Circalittoral mixed sediments.
Some variation in sediment type was observed between sampling stations with those located closer to shore along the cable route having typically coarser sediments than stations located within the OWF array area. The majority of stations sampled were characterised by sand representing broad scale habitat (BSH) A5.2 (Sand and Muddy Sand). Four stations were classified as A5.1 (Coarse Sediment), two stations as A5.3 (Mud and Sandy Mud) and one station as A5.4 (Mixed Sediment).</td><td>also comprised extensive areas of high energy infralittoral and circalittoral rock (EUNIS A3.1/ A4.1), which can be found within Freshwater West. These habitats (with the exception of high energy infralittoral and circalittoral rock (EUNIS A3.1/ A4.1) which are representative of the Annex I habitat, namely reefs.
The preliminary habitat assessment (Llŷr Floating Offshore Windfarm, Benthic Characterisation Survey 2022: Preliminary Habitat Assessment Report. REF: OEL_NSELLY0122_HA) showed that the offshore cable corridor would cross over the following habitats:
• A4.13: Mixed faunal turf communities on circalittoral rock
• A5.35: Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud;
• A5.26: Circalittoral muddy sand;
• A5.25: Circalittoral fine sand; and
• A5.44: Circalittoral mixed sediments.
Some variation in sediment type was observed between sampling stations with those located closer to shore along the cable route having typically coarser sediments than stations located within the OWF array area. The majority of stations sampled were characterised by sand representing broad scale habitat (BSH) A5.2 (Sand and Muddy Sand). Four stations were classified as A5.1 (Coarse Sediment), two stations as A5.3 (Mud and Sandy Mud) and one station as A5.4 (Mixed Sediment).</td></tr>
<tr><td>Fish spawning and nursing grounds</td><td>Consultation with Centre for Environment, Fisheries and Aquaculture Science (CEFAS) is recommended to discuss the location of the spawning areas and any mitigation measures required.</td><td>Consultation with CEFAS is recommended to discuss the location of the spawning areas and any mitigation measures required.
The following was identified the Spawning and Nursery Grounds Layers for Selected Fish in UK Waters in 2010, CEFAS.</td></tr>
</table>

Criterion	West Angle Bay	Freshwater West
	The following was identified the Spawning and Nursery Grounds Layers for Selected Fish in UK Waters in 2010, CEFAS[22]. Nursery Grounds identified in ICES rectangle 31E4 and 32E4 include tope shark (*Galeorhinus galeus*), European hake (*Merluccius merlucciuse*), mackerel (*Scomber scombrus*), anglerfish (*Lophiiformes*), spotted ray (*Aetobatus narinari*), thornback ray (*Raja clavate*), and whiting (*Merlangius merlangus*). These are all low intensity nursey grounds. Spawning Grounds identified in ICES rectangle 31E4 and 32E4 include European hake, horse mackerel (*Trachurus trachurus*), ling (*Molva molva*), mackerel, and whiting These are all low intensity. The following are also identified in the ICES rectangles as high intensity spawning grounds: cod (*Gadus morhua*), plaice (*Pleuronectes platessa*), sandeel (*Ammodytes marinus*), and sole (*Solea solea*).	Nursery Grounds identified in ICES rectangle 31E4 and 32E4 include tope shark, European hake, mackerel, anglerfish spotted ray, thornback ray, and whiting. These are all low intensity nursey grounds. Spawning Grounds identified in ICES rectangle 31E4 and 32E4 include European hake, horse mackerel, ling mackerel, and whiting. These are all low intensity. The following are also identified in the ICES rectangles as high intensity spawning grounds: cod, plaice, sandeel, and sole

Table 2-2. Offshore export cable corridor summary

Criterion	Preference
Seabed geology and surface sediments, conditions and geohazards	Freshwater West
Pipelines and Cables, including Project Erebus and Greenlink	Freshwater West
Renewable energy sites e.g. windfarms and wave energy	West Angle Bay
Ports and anchorage areas	Freshwater West
Shipping	Freshwater West
Commercial fishing e.g. fish farms	No preference
Cultural heritage e.g. wrecks	West Angle Bay
Military areas	West Angle Bay
Dumped munitions and UXO	No preference

[22] https://data.cefas.co.uk/view/153

Criterion	Preference
Aggregate extraction sites	No preference
Disposal areas and dredging	No preference
Protected sites e.g., SAC, SPA, SSSIs, Ramsar sites, MCZ	Freshwater West
Annex I Habitats	No preference
Benthic Habitat	No preference
Fish spawning and nursing grounds	No preference

2.7 Offshore Export Cable Engineering Feasibility

2.7.1 High Voltage Alternating Current (HVAC) Cable Design

Each Project Llŷr array area will export electricity to the point of connection through a single circuit comprising a single, 3 core HVAC 66 kV, subsea cable. Export cables for both arrays will be located within the same offshore export cable corridor.

A CymCap® calculation (Appendix B) was undertaken to assess the minimum spacing and burial depth for the Project Llŷr offshore export cables. This calculation is based on the cable design parameters determined by Llŷr Floating Wind Limited (Appendix A). The calculation concluded that, for a flat formation where the installation method is direct burial, the target depth should be 1.5 m and the maximum installation depth should not exceed 2 metres for export cables spaced 10 m apart (the minimum spacing distance considered practical). This is illustrated in **Figure 2-12**.

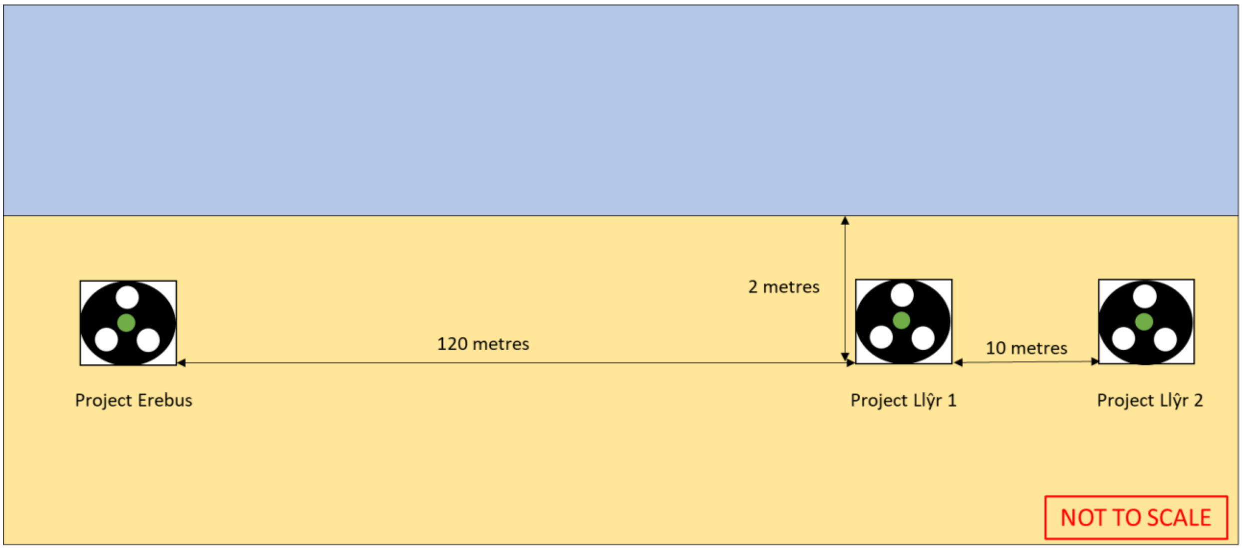


Figure 2-12. Project Llŷr and Erebus Offshore Export Cable Corridor Arrangement

2.7.2 Cable Crossings

Cable spacing must consider crossings of existing linear infrastructure such as power cables, telecom cables, and pipelines (**Figure 2-5**). The Project Llŷr offshore export cable corridor will cross four subsea cables, SOLAS cable (Vodafone), Gemini North – Seg 2, TATA Atlantic North, and the Greenlink Interconnector.

A single offshore crossing of the Greenlink Interconnector will be needed if landfall occurs either at West Angle Bay or west of the Greenlink Interconnector landfall site. The location of this crossing is Turbot Bank.

These cables will need to be crossed at an angle as close to 90 degrees as possible, and no less than 45 degrees, to minimise risk of impacts on the installed linear facilities and improve access for subsequent maintenance. At the four crossing points, more lateral space may be required for cables approaching at an oblique angle to accommodate any bending necessary to cross closer to 90 degrees (**Figure 2-13**).

The final configuration of the cables at the crossing points will depend on agreement with the owner of the existing infrastructure, as permission will be required to cross. It is anticipated that this will be obtained through consultation with the owner before the detailed design stage.

The Project Llŷr offshore export cables may also require a protection structure (e.g., concrete mattress, rock armour) to separate the cable from an underlying cable or pipeline. As the offshore export cable will lie either on the seabed or be buried shallower than planned at these crossing points, it will also require additional protection from potential hazards such as bottom fishing gear, anchor strike and unburial because of seabed erosion. Appropriate cable protection will be determined at the detailed design stage by undertaking a cable burial risk assessment (CBRA).

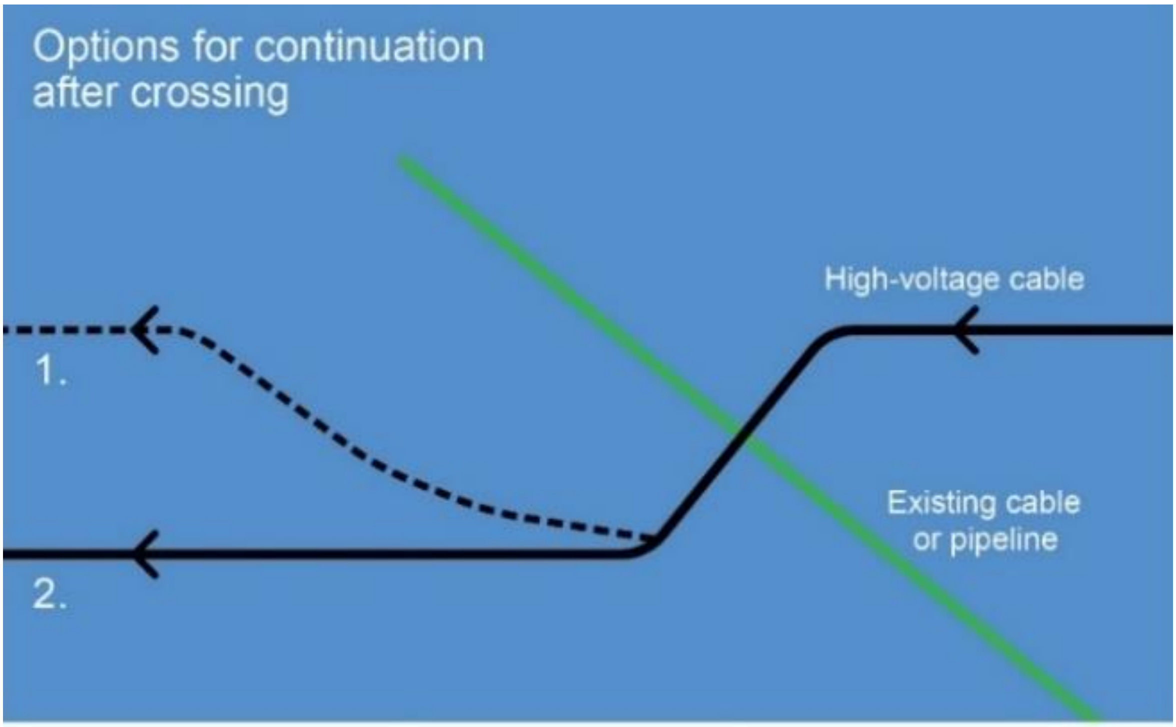


Figure 2-13. Cable Crossings of Other Cables or Pipelines

2.7.3 Cable Maintenance and Repairs

Once buried, offshore cables do not require routine maintenance. However, regular operation and maintenance (O&M) inspections will need to be undertaken. At the detailed design stage, the potential future risk of cable exposure will need to be assessed in order to define the frequency and location of these inspections.

In the event of cable failure, or unplanned exposure, the cable will need to be reburied and additional protection installed to maintain the burial depth and cable protection. The width of the cable corridor and the spacing between the Project Llŷr and Project Erebus offshore export cables must be sufficient to allow for cable repair in the same location as well as O&M inspections.

Repair bight is a function of water depth, deck height, and required length on the deck of the cable repair vessel. As a result, repair bights are longer in deeper water and shorter in shallow water. The combined length determines the width of the required area for the repair bight on the seabed. Common industry guidance for the space between cables to accommodate a repair bights is 3 times the water depth (ICPC 2014; DNV GL 2018).

Using this approach and available bathymetry, for the Project Llŷr offshore export cables, it is recommended that the offshore export cable corridor includes a 120 metre buffer (excluding any error allowance) on one side of each cable for a repair bight. This would therefore require a minimum of 120 metre separation between the Project Llŷr and Project Erebus offshore export cables (**Figure**

2-12). If the pair of Llŷr offshore export cables are positioned 10 m apart, the overall width of the Project Llŷr offshore export cable corridor could then be reduced to 250 metres (**Figure 2-14**). However, this would then provide limited scope for micro-siting of the cables on the seabed and no error allowance for cable repair. A 300 metre wide cable export corridor would increase this scope, incorporate some cable repair error allowance and provide some additional width for localised widening of the lateral spacing of the export cables at crossing points. Generally, a 300 m wide corridor can be maintained between the boundary of the Llŷr [*offshore*] survey area and the indicative route of the Project Erebus export cable(s). However, at one location, the width available within the Llŷr [*offshore*] survey area does narrow to approximately 270 m when account is taken for the Project Erebus export cable corridor.

Industry best practice would be to obtain consent for a 500 metre wide export cable corridor which maintains a separation distance with an adjacent corridor which is sufficient to affect a cable repair (typically this would be increased from a minimum of 120 m to, say, 150 m between the Project Llŷr and Project Erebus offshore export cables to include an error allowance). This could be achieved whilst remaining within the Llŷr Offshore Project Boundary but would require the extent of the Llŷr [*offshore*] survey area to be increased.

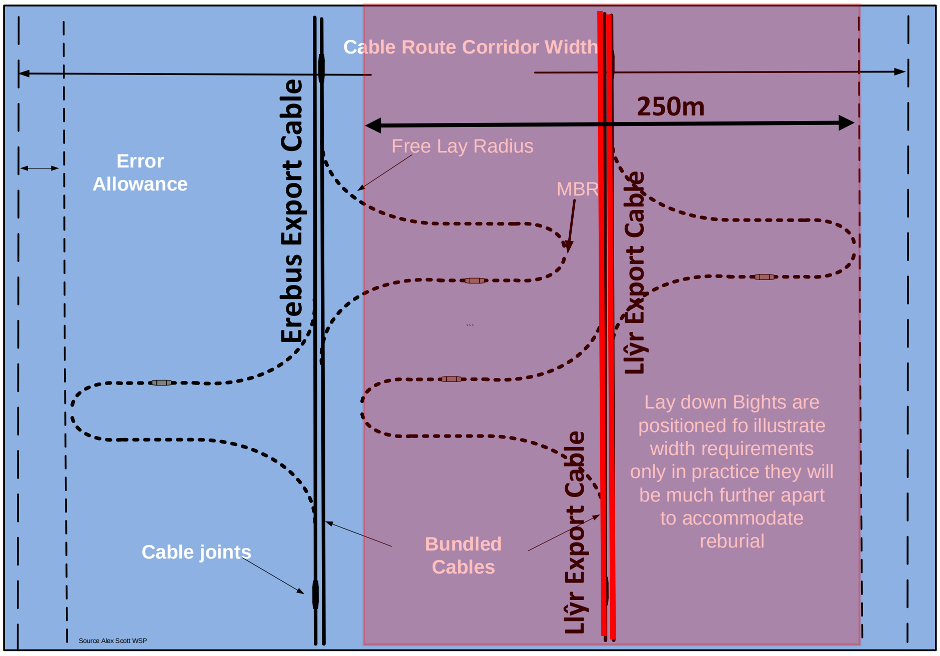


Figure 2-14. Repair Bight and Cable Corridor Requirement for a Multiple Cables with Shared Space for Repair Bight. NOT TO SCALE. Source: DNV GL (2018)

2.8 Offshore Export Cable Installation Methodology

2.8.1 Pre-installation Activities and Survey requirements

Various surveys will need to be completed prior to any installation of the offshore export cable; these will include:

- Detailed engineering surveys;
- UXO clearance survey; and
- CBRA.

2.8.2 Seabed preparation, Route clearance and Pre-lay grapnel run

The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) identified 184 items of debris, 6969 boulders, and various boulder fields within the survey area. Boulder fields have largely been avoided when routing the offshore export cable corridor. However, where debris and boulders have been identified, these items will need clearing prior to installation. Dedicated boulder grab equipment will need to be used to move larger boulders (more than 30 cm) to a location approximately 15 m perpendicular to the cable route. The intent would be to relocate boulders within the Llŷr Offshore Project Boundary and not to remove boulders from the seabed. The preferred boulder clearance method would be by SCAR Plough. Project Erebus anticipate 12 kilometres of SCAR ploughing. It is anticipated that a similar length of ploughing will be required for Project Llŷr.

If any UXO were identified in the UXO clearance survey, these objects will also need to be dealt with.

Sandwave and megaripples will also require levelling; these features were identified in the geophysical survey. Project Erebus note that 3900 metres of seabed require sandwave levelling for their installation. It is assumed that this will be similar for Project Llŷr.

Immediately prior to the installation, a pre-lay grapnel run (PLGR) will be required. This is where a heavy grapnel with a series of specially designed hooks, or grapnels, with approximately 1 metre width and 0.5 metres to 1 metre penetration depth, will be towed along the centre line of the cable route by either a work boat or the cable lay vessel. Debris retained by the grapnel will be collected on board and disposed of appropriately through licensed onshore facilities.

2.8.3 Installation operations, Cable burial and protection

For Project Llŷr, a target average installation depth of 1.5 metres is considered appropriate [*1.5 metres is standard practice; target installation depths will be confirmed in the CBRA*], although this may vary depending on the nature of the substrate. For example, in areas where there is evidence of trawling activity or areas of mobile seabed (sandwave) the cable burial depth may need to be increased.

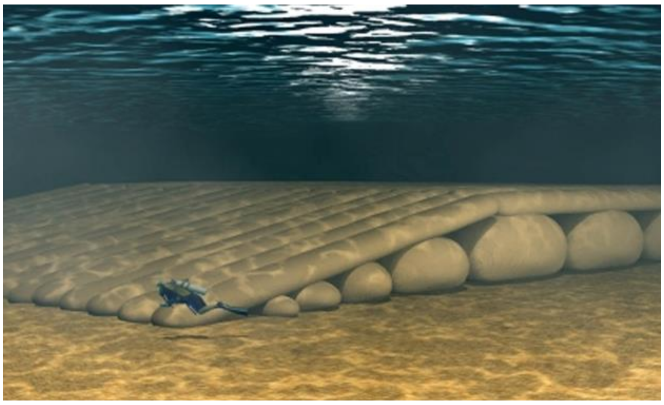
The preferred cable burying method is jet trenching burial, where seabed composition allows. Jet trenching burial is carried out by a remotely operated tracked trenching machine which buries the cable to a target depth of 1.5 metres using water jetting. Another method is the use of a subsea cable plough towed on the seabed behind the cable laying vehicle (or by a remotely operated vehicle as a separate activity). Jet trenching burial is preferred due to the reduced environmental impact, when physically burying the cable, and is more efficient when compared to ploughing. Further investigation, including an appropriate level of site investigation and a CBRA will need to be undertaken to ensure optimal burial depths and methods are selected for the cable installation activities.

Where the nature of the seabed prevents cable burial, or where the minimum cable burial depth cannot be achieved, additional cable protection is likely to be needed. These measures would be considered for specific localised areas, identified through the CBRA (**Figure 2-15** and **Figure 2-16** show indicative areas where seabed preparation or increased installation depth may be required).

Alternative methods of cable protection are listed in **Table 2-3**.

Table 2-3. Alternative Cable Protection Methods

Type of Cable Protection	Image
Vertebrae steel Bend Restrictors (VBR's). In terms of cable crossings, VBR's protect both the newly installed cable and the crossed cable. They also provide separation between the two assets to limit and minimise thermal and electromagnetic interference. VBR's may be installed as a standalone crossing protection if suitable, or used in combination with concrete mattresses if further stability or protection is required. VBR's are maintenance free for their design life.	
Anti-Scour Frond mattress. The flow of water around this under certain conditions can cause erosion of the seabed; this is called scour. It may be gradual or rapid, but it is cumulative, and the end result may be unsafe spans on cables generally. Natural seaweed reduces water velocity locally and correspondingly reduces scour. Frond Mattress replicates this natural phenomenon (either directly onto the seabed or attached to a Flexi mat).	

Type of Cable Protection	Image
Articulated Cast iron shells. The use of cast iron for offshore ballasting shells ensures cable protection, stability, strength, and performance due to the mechanical properties of the material able to withstand the harshness of marine environments.	
Grout bags. Grout, Sand, or Gravel usually packed into 1 tonne multiple trip bags. The materials are used for filling voids and general support to the other cable protection options; grout bags will cure after deployment to provide a permanent stable support. Drop bags are an alternative option giving the option of safely deploying grout, crushed stone or other loose materials. various sizes and shapes can be used. **Rock Bags.** Rock Filter Bags can be used for Scour Protection, Span Correction, Cable Protection & Flowline Protection. The Rock Filter bags are an environmentally acceptable solution by using recycled materials. Due to high flexibility of the Rock Filter Bags, it is possible to fill spans by using multiple bags. Using specialist handling equipment, it is possible to install many Rock Filter Bags at a time.	 

Type of Cable Protection	Image
Concrete Mattresses. Concrete mattresses are a recognised solution for cable crossings. Generally, the crossed asset is covered first with a concrete mattress, followed by the crossing asset being laid on top. Another concrete mattress is then placed on top of the crossing asset, securing it in place and providing mechanical protection against over trawling and impact, and providing stability to reduce abrasion risk. The concrete mattresses provide a high degree of flexibility, allowing it to closely follow the contours of a cable and seabed. It is constructed using high strength concrete profiled blocks and U.V. stabilised polypropylene rope. Once installed, mattresses may scour into the seabed to increase the stability and over trawlability. Extreme seabed, current and wave conditions may determine that additional stability is required beyond that provided by the standard mattresses. In some cases, mattresses with enlarged tapered edge elements offers an improved over trawlability profile.	

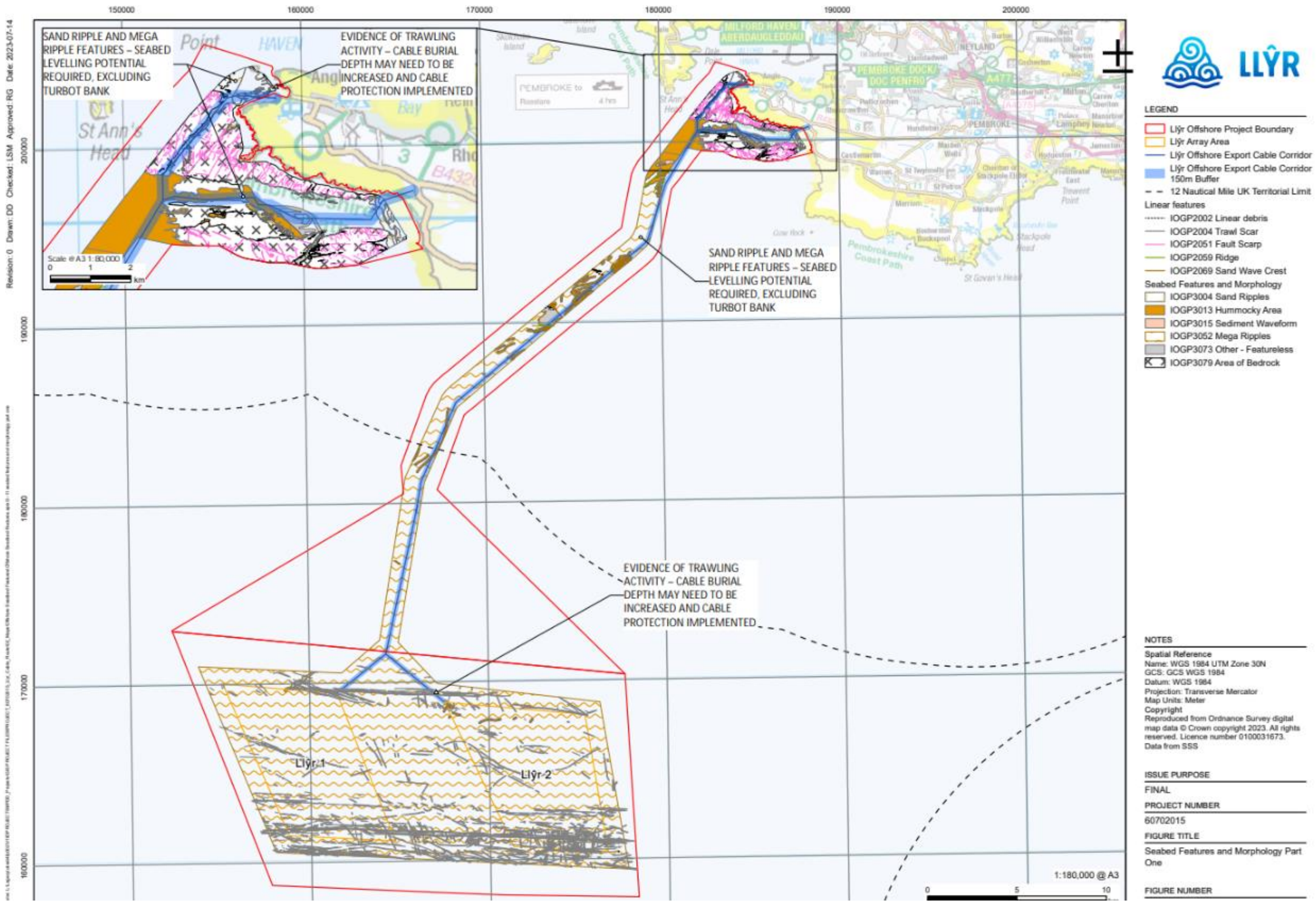


Figure 2-15. Seabed preparation and installation, indicative areas part one

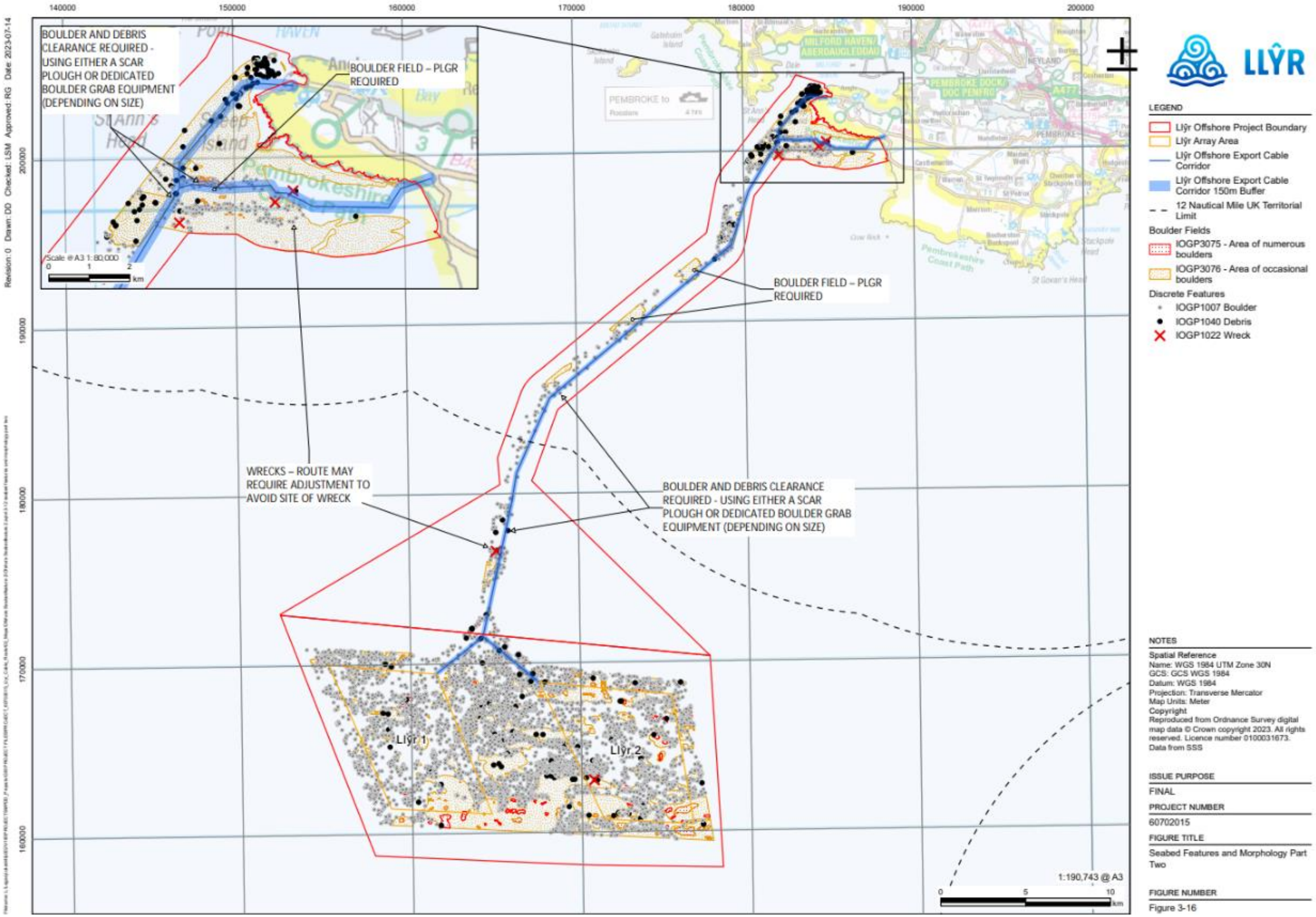


Figure 2-16. Seabed preparation and installation, indicative areas part two

3 MITIGATION MEASURES FOR ANNEX I HABITATS

3.1 Overview

A primary reason for the designation of the Pembrokeshire Marine / Sir Benfro Forol SAC, is the presence of extensive areas of the Annex I listed 'Reef' habitat. Extensive areas of sublittoral rocky reef stretch offshore from the coastline and between the Pembrokeshire islands. These reefs support extensive areas of tide-swept kelp and species-rich red algal populations and, across the large areas of deeper rock reef, a wide range and abundance of invertebrate animal communities, with hydroid, bryozoan, soft coral, and anemone species[23].

Other Annex I habitats present as a qualifying feature, but not a primary reason for selection of the SAC includes, but are not limited to, 'Sandbanks which are slightly covered by sea water all the time', and 'Mudflats and sandflats not covered by seawater at low tide'.

Figure 2-7 shows the potential areas for Annex I Sandbanks and Reefs. However, this is only an indicative area, with very poor confidence stated. The exact location and extents of all the Annex I Habitats cannot be confirmed without benthic surveys of the seabed. At this stage, the percentage of interaction between the Project Llŷr offshore cable corridor and Annex I Habitats in the nearshore is unknown; previous survey work undertaken by Project Erebus and Greenlink has identified the presence of reefs and sandbanks within their offshore cable corridor.

3.2 Review of Project Erebus and Greenlink Mitigation

Both Project Erebus and Greenlink undertook extensive engagement with NRW, Joint Nature Conservation Committee (JNCC), and other key stakeholders to better understand the implications of cable burial and protection on Pembrokeshire Marine SAC Annex I Habitats.

Extensive work was undertaken to determine the seabed conditions along the entire route and an initial cable burial assessment. The initial review for Project Erebus concluded that the majority of the cable was expected to be buried, however, areas were identified where burial may not be possible due to seabed conditions i.e., presence of bedrock at the seabed surface or close to seabed level or where high-density boulder fields are present[24].

The burial assessment for Project Erebus informed the potential interaction between cable protection and Annex I Habitats within the Pembrokeshire Marine SAC, with a focus on permanent habitat loss impacts to Annex I Reef (H1170) and Sandbank (H1110) habitat. Impacts were identified from the potential placement of rock armour directly on Annex I habitat (cable protection, cable crossing) and / or damage to Annex I Reef caused by open cut trenching within the intertidal area.

Cable protection for Project Erebus at the Greenlink crossing would also coincidently interact with the Annex I Turbot sandbank.

It is assumed that the same impacts identified by Project Erebus and Greenlink will also be associated with the Project Llŷr offshore cable corridor. However, further survey results of the nearshore area are required before undertaking the next stage of corridor refinement.

[23] https://sac.jncc.gov.uk/site/UK0013116
[24] https://www.bluegemwind.com/wp-content/uploads/2020/07/Erebus-ES-Vol-1-Chapter-3-Site-Selection-and-Alternatives-final.pdf

3.3 Reefs

Stony Reef and Bedrock Reef may be of high environmental value, as they may contain more delicate species such as rugose squat lobsters, ascidians and sponges that take longer to re-colonise hard substrata and grow to adult size. Recoverability of such habitats is expected to take longer, and therefore the overall magnitude of effect from cable installation could be higher in Reef habitat.

If Bedrock Reef is identified within the Project Llŷr offshore survey area, that overlaps the offshore cable corridor, it should be avoided through careful re-routing. However, it is understood that rerouting may not be possible. Any outcropping rock that may require crossing and may also require external cable protection, if identified.

In addition, if medium grade Stony Reef is identified, it may be possible to bury the cables in this area, but some boulder clearance may be required. If this is needed, large cobbles and boulders would be pushed to either side of the corridor centreline. Although, the potential effects are highly localised, abrasion is likely to have short-term effects on the species inhabiting the Reef habitat. There is also a potential that the use of external cable protection will reduce the range (extent) of the habitat within the site.

The Project Erebus consent boundary for the offshore export cable corridor narrows through Row's Rock channel, at the entrance to Milford Haven in order to avoid the raised bedrock reef on either side of the channel. Greenlink nearshore sections of the route were also refined to follow a sand channel through the bedrock reef habitat. These two refinements reduced the effect on Annex I Bedrock Reef. As there is unlikely to be sufficient space in either of these channels to also route the Project Llŷr offshore cables, whilst maintaining an acceptable 120 metres separation distance with the cables of other developers, an alternative route to landfall in the nearshore area will be required.

The geophysical survey (Llŷr Floating Offshore Windfarm, Marine Survey, Geophysical Results report, DOC NO: NSW-PJ00301-RR-DC-SUR-001) has identified the primary sediment classification in the nearshore area for both West Angle Bay and Freshwater West. It is noted that without the nearshore benthic habitat survey data, at the time of writing, it is assumed that anything classed as 'IOGP3205 Rocky' in the study area is Annex I reef. Nearshore data, when available, will be checked against these finding and assumptions; the report will highlight whether the reef are 'Stony' or 'Bedrock' and provide a detailed assessment of whether it is low, medium, or high grade.

The geophysical survey confirmed the existence of Row's Rock channel on the approach to West Angle Bay. Initial review indicates that the channel width varies between 400 metres and 1,200 metres. It is thought that a shared corridor for Project Llŷr and Project Erebus would need to be a minimum of 380 metres. A more detailed review of the Row's Rock channel width and cable spacing for the two projects is required to confirm landfall is possible.

With regards to Freshwater West, routing to landfall may be possible by following the channel identified as 'IOGP3204 Sandy-clay', which avoids the rocky sediment in the east of the survey area. A boulder field exists within this channel, which would require extensive clearing. Although, routing may be possible to the south of the boulder field to avoid this. Access to detailed mapping is required to confirm this. Beyond the boulder field, routing is possible though a section identified as 'IOGP2102 Sand' and 'IOGP3104 Clay'. Megaripples identified in this area will require levelling. Furthermore, in the section identified as clay, the offshore export corridor will need to be routed around the Bombora Wavepower and META sites.

3.4 Sandbanks

The Turbot Bank sandbank is exposed to wave action, suggesting that epifauna and infauna present will be characteristic of moderately strong tidal currents, and given the dominance of sand and coarse sediments, can be viewed as adaptable to physical disturbance. Once installation activities have ceased the seabed will still be suitable for recolonisation from the surrounding area. However, this assumes that burial is possible on the sandbank, if external protection is used this may interrupt the physical processes.

The Project Llŷr preliminary benthic habitat survey area crosses the Turbot Bank and identified that two habitat classifications are present on this feature; A5.25 Circalittoral fine sand and A5.44 Circalittoral mixed sediment.

Burial in sediment should be achievable in this area without the need for pre-sweeping or external cable protection, this will need to be confirmed by CBRA. However, an area of protection is required for the Greenlink cable crossing, which overlaps the far western extent of the Turbot Bank sandbank feature within the SAC. The Turbot Bank sandbank is part of a dynamic system, often reworked by strong tidal currents and over time, rock protection may become buried and any localised loss of the biotope would not be permanent.

Project Erebus have proposed the use of rock berms at their cable crossing with Greenlink on Turbot Bank, after extensive consultation with JNCC and NRW. AECOM propose that the use of rock bags, shown in **Figure 3-1** and **Figure 3-2.** , are considered. However, further design information is required on Greenlink cable installation before recommendations are confirmed.

Rock bags provide stability for the cables by preventing movement with strong tidal currents and they provide cable protection. Unlike rock berms, which are dumped directed onto the seabed and could possibly be reworked. If repairs to the cable were required, rock bags can be lifted off the cable as required for repair, or at the end of the project's life. Whereas rock berms would need to be excavated. It is noted that rock bags and rock berms can develop marine life and accumulate sediment, and once established it may be deemed better to leave in position. Another cable protection to consider is articulated cast iron shells/pipe. Articulated split pipe protection consists of interlocking cast iron (impact resistant) pipe halves, which lock together to protect the cable from abrasion or other external damage. This option will protect both the newly installed cable and the crossed cable, while providing separation between the two assets to limit and minimise thermal and electromagnetic interference. At Turbot Bank, steel lined protection could be used to sink the cable into the sandbank.

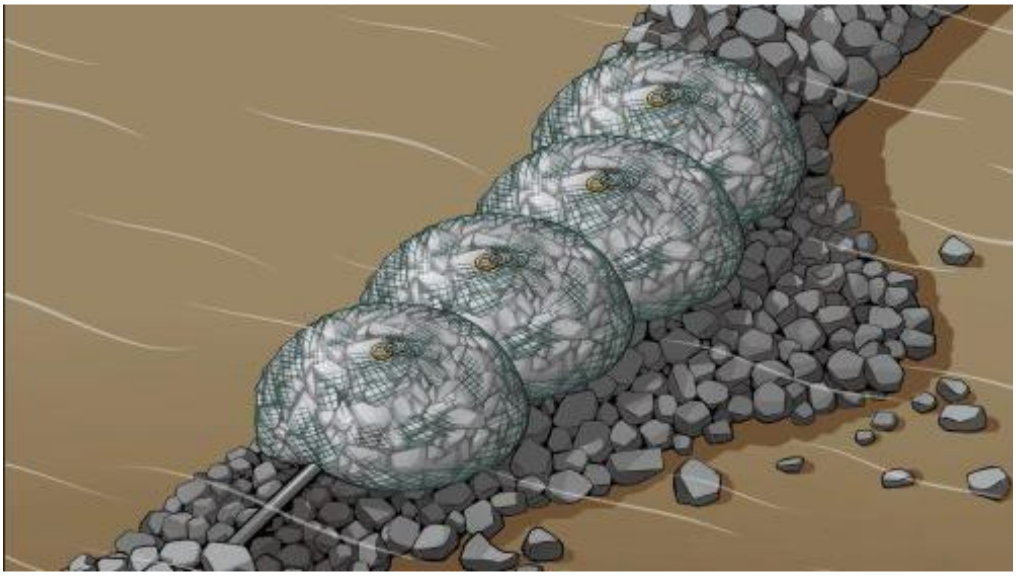


Figure 3-1. Rock Bags, rocks are elected based on size and desired slope

Figure 3-2. Rock protection in situ

3.5 Mudflats and sandflats not covered by seawater at low tide

Open cut trenching across the intertidal zone, will interact with Annex I mudflats and sandflats features and cause temporary habitat disturbance[25]. Given the environmental constraints, the only viable construction method is to use HDD to install a duct, through which the subsea cables can pass from an area beyond mean low water to landfall site outside of the protected areas. This technique is required to avoid open cut trenching on the beach and through the shallow subtidal and intertidal marine habitats.

Within the upper beach terrace, at Freshwater West, an area of consolidated coarser sediment is covered by a sand veneer. Disturbance to this feature could create a weakness, potentially allowing a

[25] https://www.rpsgroup.com/media/4295/review-of-cable-installation-protection-mitigation-and-habitat-recoverability.pdf

scour channel to form, which in turn could affect the way sediment is transported on and off the beach.

The presence of external cable protection in the offshore region of this Annex I Habitat may cause very localised changes in water flows. This in turn could cause localised scour. Scour will only occur in areas of sediment where bottom current either already exceed the critical bedload parting velocity, or where external cable protection results in an increase in current velocity to above the critical bedload parting velocity.

4 CONCLUSION

This report has assessed the hard and soft environmental and engineering constraints, both offshore and at landfall, for an export cable corridor located inside the Llŷr [*offshore*] survey area. This corridor is:

- located inside the offshore scoping boundary and both the offshore and nearshore survey areas;
- has one variant leading to landfall at West Angle Bay and another leading to landfall at Freshwater West; and
- follows the eastern edge of the offshore survey area to minimise the extent of interaction with the Project Erebus export cable corridor.

The corridor has been derived through consideration of both the landfall locations and by considering the following principles:

- routing options needed to be able to connect to viable landfall locations;
- the number of existing pipeline and cable crossings to be minimised as far as possible;
- where a crossing is required, cables and pipelines to be crossed at 90 degrees where possible;
- historic wrecks to be avoided as far as possible;
- avoidance of other infrastructure, dredging areas, disposal areas etc with suitable buffers;
- avoidance of designated sites as far as possible; and
- avoidance of ecologically important sandbanks and potential reefs as far as possible.

The study assumes each Project Llŷr array area will export electricity to the point of connection through a single circuit comprising a single, 3 core HVAC 66 kV, subsea cable and that export cables for both arrays will be located within the same offshore export cable corridor.

Based on this assumption, a CymCap® calculation was undertaken to assess the minimum spacing and burial depth for the Project Llŷr offshore export cables. The calculation concluded that, for a flat formation where the installation method is direct burial, the target depth should be 1.5 m and the maximum installation depth should not exceed 2 metres for export cables spaced 10 m apart (the minimum spacing distance considered practical).

Through consideration of bathymetry and the repair bight requirement for a multiple cable corridor within a shared space, it is recommended that a minimum width of 120 m wide should be maintained on one side of each Project Llŷr export cable to facilitate a cable repair. If the pair of Llŷr offshore export cables are then positioned 10 m apart, the overall width of the Project Llŷr offshore export cable corridor could be reduced down to 250 metres. However, this would then provide limited scope for micro-siting of the cables on the seabed and no error allowance for cable repair. A 300 metre wide cable export corridor would increase this scope, incorporate some cable repair error allowance and provide some additional width for localised widening of the lateral spacing of the export cables at crossing points.

Adopting a 300 m wide export cable corridor which remains within the Llŷr [*offshore*] survey area would necessitate overlapping with the Project Erebus export cable corridor over a distance of approximately 19 kilometres. However, a 300 m wide export cable corridor can generally be maintained between the boundary of the Llŷr [*offshore*] survey area and the indicative route of the Project Erebus export cable(s) although the width available within the Llŷr [*offshore*] survey area does narrow to approximately 270 m in one location.

Industry best practice would be to obtain consent for a 500 metre wide export cable corridor which maintains a separation distance with an adjacent corridor which is sufficient to affect a cable repair (typically this would be, say, 150 m between the Project Llŷr and Project Erebus offshore export cables to include an error allowance). This could be achieved whilst remaining within the Llŷr Offshore Project Boundary but would require the extent of the Llŷr [*offshore*] survey area to be increased.

Routing of the offshore cable corridor to Freshwater West would pass close by to the Bombora Wavepower and META lease areas and is likely to encroach upon the Castlemartin Range Sea Danger Area within Freshwater West bay. At West Angle Bay, whilst the offshore cable corridor would pass through the Castlemartin Range Sea Danger Area, both the Bombora Wavepower and META lease areas will be avoided.

Freshwater West interacts with four environmentally designated sites and West Angle Bay interacts with six sites. An offshore export cable corridor for the landfall site at West Angle Bay will encroach into the shipping lane at the entrance to Milford Haven and will require consultation with Milford Haven Port Authority (MHPA) to ensure safe passage of the cable installation vessel. The offshore export cable corridor for Freshwater West would also encroach onto the entrance to Milford Haven, but not the shipping lane, and whilst still requiring consultation with MHPA is less likely to result in restrictions on cable installation.

The geophysical survey identified that there are 77 items of debris and one wreck in the export cable corridor leading to landfall at West Angle Bay. This compares with 31 items of debris and four wrecks which were identified in the export cable corridor leading to landfall at Freshwater West. Further UXO clearance surveys are required.

The Project Llŷr offshore cable corridor crosses at least four existing subsea cables: SOLAS cable (Vodafone), Gemini North – Seg 2, TATA Atlantic North, and the Greenlink Interconnector. These cables need to be crossed as close to 90 degrees as possible. As the Project Llŷr export cables will be the ‘crossing cables’, they will need to either lie on the seabed or be buried to a shallow depth where the crossing point occurs; this is to maintain adequate clearance to the infrastructure being crossed. Through initial evaluation of the nature of the seabed, it is considered that rock bags could be a good option to separate, anchor and protect the crossing cable at the crossing point; other solutions could include concrete mattresses, rock armour or split cast iron ducts. A CBRA will be required to confirm this.

The crossing of the Greenlink Interconnector occurs at an Annex I Habitat identified as Turbot Bank Sandbank. The use of rock bags at this crossing location will keep the rocks contained, mitigating the risk of the rocks spreading across the sandbank. Such a solution will require further evaluation through consultation with Greenlink and NRW. Where the Project Llŷr export cables pass through the remainder of this sandbank, burial avoiding pre-sweeping or external cable protection is considered preferable as this will minimise disturbance to the seabed, which could result in physical change as well as permanent habitat loss.

With regard to Annex I Habitats, nearshore survey information is required to confirm the extent of any potential Annex I Reefs. At this stage, it has been assumed that sediment identified as Rocky in the geophysical survey is all Annex I Reef. Both Project Erebus and Greenlink undertook extensive engagement with NRW, JNCC, and other key stakeholders to better understand the implications of cable burial and protection on Pembrokeshire Marine SAC Annex I Habitats. As a result of this, both projects were able to identify channels in the nearshore region that avoided bedrock reef.

For landfall at West Angle Bay, Project Llŷr may be able to share the Row's Rock channel on the approach to West Angle Bay with Project Erebus. A study will need to be undertaken to determine the extent of the separation required between the Project Erebus and Project Llŷr export cables to avoid any detrimental effects on cable ratings; this would typically need to consider required rating, cable separations and burial depth.

For landfall at Freshwater West, the offshore cable corridor identified approaches landfall via a sandy-clay channel, between rocky-subcrop. Detailed analysis of the boulder field here will be required to understand exact routing and whether extensive boulder clearance will be required. From the boulder field, the offshore corridor will then pass through an area of Megaripples and then south of the Bombora Wavepower and META areas. If the Freshwater West landfall site is chosen a study will also be required to determine the extent of separation from the Greenlink Interconnector in the nearshore area on the approach to landfall.

In the event that routing to these landfall sites is not viable, then an alternative landfall site outside of the current scoping boundary, for example Freshwater East, may need to be considered.

Appendix A Export Cable Assumptions

A.1 Cable Parameters

The offshore wind turbine generators are connected with 66 kV dynamic submarine cables, an example of the parameters is provided in **Table A-1** below.

Table A-1. Example offshore export cable parameters from client

Parameter	Unit	Quantity
Cross section	mm^2	1000 (TBC)
Number of cores	-	Three
Conductor type	-	Cu
Nominal voltage	kV	66
Circuit length – Llŷr 1	kilometres	48.00
Circuit Length – Llŷr 2	kilometres Ω	49.63
Positive sequence resistance	Ω / kilometres	0.04
Positive sequence reactance	Ω / kilometres	0.08
Zero sequence resistance	Ω / kilometres	0.25
Zero sequence reactance	Ω / kilometres	0.36

Appendix B CymCap® Cable Calculation Results

CYMCAP® software can be used to design power cables and calculate their electrical parameters, as well as calculate the current carrying capacity and thermal effects of cables for installation conditions.

Table B-1 and **Table B-2** outlines the cable electrical parameters used in the calculation; **Table B-3** shows the cable installation parameters.

Table B-1. Cable components used in calculation [Source: Client provided information]

Cable Components	Design
Conductor Size	1000 mm²
Number of Cores	3
Conductor	Stranded Plain Annealed Circular - Copper
Conductor Screen	Semi-Conducting Compound
Insulation	XLPE
Insulation Screen	Semi-Conducting Compound
Sheath	Aluminium
Armour Bedding	Compounded Jute
Armour	Steel Wire Armor
Armour Bedding 2	Compounded Jute
Armour 2	Steel Wire Armor
Outer Jacket	Polyethylene
Outer Diameter	191.5 mm

Table B-2. Electrical parameters used in calculation [Source: Client provided information]

Electrical Parameters	Value
Voltage	66 kV
Frequency	50 Hz
Thermal Resistivity (Assumed)	1.0 k.m/W
Ground Temperature (Assumed)	15 °C
Conductor Temperature (Normal Operation)	90 °C
Daily Load Factor	0.95
Required Rating (TBC by Client)	100 MW
Required Current Rating Per Cable	925 A (approximately)

Table B-3. Installation parameters used in calculation [Source: Assumed Values]

Installation Parameters	Value
Type of Bonding	Single Point Bonding
Cable Formation	Flat formation
Cable Installation	Direct Buried
Maximum Installation Depth	2 m
Spacing between Circuits	10 m

Calculation Results

Figure B-1 below shows the CymCap® model output and **Table B-4** the resulting ratings for the cables.

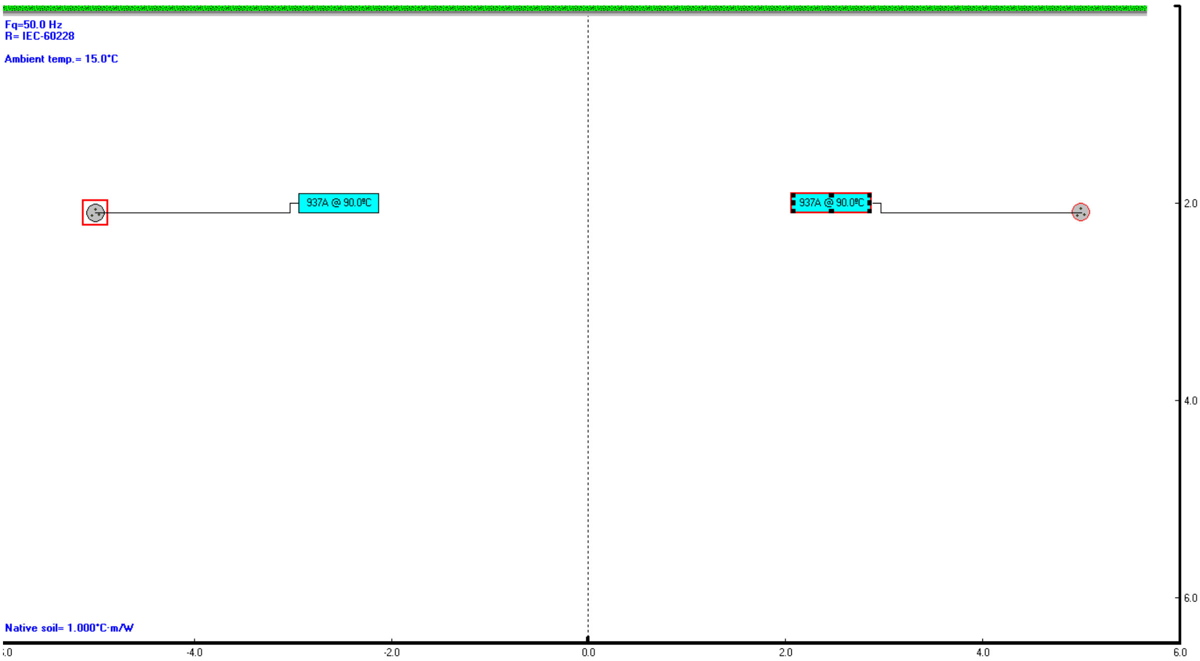


Figure B-1. Model output

Table B-4. CymCap® Cable Calculation results for Project Llŷr

Parameter	Value
Current Rating (CymCap Software)	937 A
Power Rating (using power factor of 0.95)	101 MW