Cenos Offshore Windfarm Limited

Cenos EIA

Appendix 1 – Preliminary CBRA and BAS Report for the Inter-Array Cables

ASSIGNMENT A100907-S01
DOCUMENT CEN001-GLM-01-IAC-ENG-RPT-0005

XODUS

Aberdeen

5th Floor Capitol Building
429-431 Union Street . Aberdeen
AB11 6DA . UK

www.xodusgroup.com

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REV	DATE	DESCRIPTION	ISSUED	CHECKED	APPROVED	CLIENT
01	19/09/2024	Issued for review	Francis Dick	Matthew Lang	Matt Owen	Flotation Energy
02	31/10/2024	Issued for client	Francis Dick	Matthew Lang	Matt Owen	Flotation Energy

Cenos Offshore Windfarm – Preliminary CBRA and BAS Report for the Inter Array Cables

Doc No	CEN001-GLM-01-IAC-ENG-RPT-0005	**Rev**	02
Alt Doc No	GM-PRJ111506-GEO-RP-0007	**Alt Rev**	
Document Status	Issued	**Doc Date**	31/10/24

Document History

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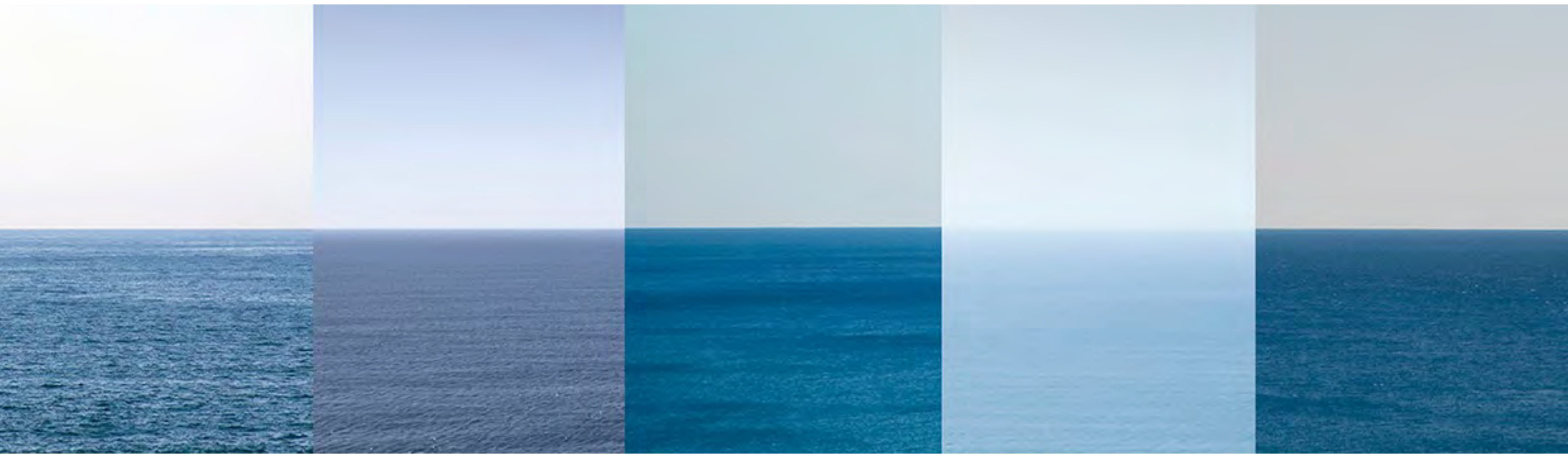
Rev	Date	Doc Status	Originator	Reviewer	Approver	Modifications
01	19/09/24	IFR	FD	KH	MO	
02	31/10/24	IFC	FD	ML	MO	Issued for client



Cenos Offshore Windfarm – Preliminary CBRA and BAS Report for the Inter Array Cables

For Flotation Energy

GM-PRJ111506-GEO-RP-0007 CEN001-GLM-01-IAC-ENG-RPT-0001

2	31-Oct-2024	Issued for Client Review	Francis Dick signed off this document electronically in the capacity of Originator at: 2024-10-31 16:36:49 UTC Francis Dick	Matthew Laing signed off this document electronically in the capacity of Reviewer at: 2024-10-31 16:39:28 UTC Matthew Laing	Matt Owen signed off this document electronically in the capacity of Approver at: 2024-10-31 16:50:25 UTC Matt Owen
Rev	**Date**	**Document Status**	**Prepared by**	**Reviewed by**	**Approved by**

Table of Contents

Figures

Tables

DOCUMENT ISSUE RECORD

Rev	Date	Status	Prepared by	Reviewed by	Approved by
1	18/09/2024	First Draft	Francis Dick	Kieran Hill	Matt Owen
2	31/10/2024	Issued for Review	Francis Dick	Matthew Laing	Matt Owen

DOCUMENT CHANGE RECORD

Rev	Section(s)	Page(s)	Brief Description of Change
1			Original Issue to Client
2			Addressing Client Comments

DOCUMENT HOLD RECORD

Section(s)	Page(s)	Brief Description of HOLD

Global Maritime Consultancy Ltd.
8 Nelson Street

NE1 5AW Newcastle upon Tyne
United Kingdom
T F
www.globalmaritime.com

1. SUMMARY

On behalf of Cenos Offshore Windfarm, Global Maritime (GM) have conducted a full CBRA and BAS study for the Inter-Array Cables (IACs) for the Cenos floating offshore wind farm. This document details the assessment of the geophysical survey data and work conducted thus far by GM for the Cenos project, including its suitability for application to the CBRA process; and both the CBRA and BAS results. Finally, based on the results of these works, a recommended method for cable installation and protection is provided.

An inter-array cable layout has been developed based on an indicative turbine layout and engineering principles specific to inter-array cable design. These principles aim to reduce total cable length, avoid crossings with the planned cables on the site, and reduce the number of crossings with the Culzean pipeline as much as possible. The cable routes provide an indicative cable length, and provide a basis for CBRA result extraction and BAS development.

A site conditions assessment has been performed to determine the geological layers of the seabed within the lease area. Within the depth of interest, this assessment found that the majority of the cable route is situated across surficial clayey sands and sandy clays, with higher-strength clays present underneath these surficial layers. Geological units were assigned in previous work done by GM, with the geotechnical properties of these inferred based on publicly available data and GM's own experience in the region. These units, with their spatial extents defined by the geophysical survey data for the lease area, could then be used in the CBRA calculation.

A Stable Seabed Level has been calculated, based on a single bathymetric survey from 2023. The resultant SSBL could not be used, due to gaps in the data, however, a general assessment of seabed mobility from the available survey data suggests that mobility across the site is minimal and does not significantly affect the CBRA outcome and cable installation and protection methodology. The SSBL output from this workflow represents a snapshot only, based on available bathymetric data, and does not account for forward modelling at this stage.

Global Maritime's optimised CBRA method was applied with modelled post-windfarm installation vessel traffic to analyse the anchor strike risks to the cable and propose target burial depths along each IAC to minimise the risk to acceptable levels whilst also maintaining practical burial depth along the cable route. This burial depth is constant along the cable routes, due to the relatively low density of modelled vessel traffic. The proposed burial depth and risk profile for the cable is detailed in the results section of this report, and in the BAS table appendix. The cable layout was engineered by GM for the study and was used as the basis for the calculation and presentation of the CBRA and BAS results.

A Burial Assessment Study (BAS) was conducted to identify a recommended method for cable installation based on the results of the CBRA and any geohazards identified along the cable routes. The routes were divided into sections based on geological conditions and localised hazards and burial methods listed. The resulting method consists of a boulder clearance campaign (subject to the results of cable micro-routing), followed by a post-lay burial campaign with a powerful jetting tool. Remedial protection is also recommended specifically at pipeline crossings and may potentially be required in the event of reduced

burial, but may not be necessary depending on what the developer deems as an acceptable risk level.

Further site investigation, including a geophysical completion campaign and a full geotechnical survey is recommended, with the CBRA to be re-run using the results of these and updated cable routes once the WTG layout has been confirmed. The BAS should also be updated following the updated CBRA and selection of cable installation assets.

2. INTRODUCTION

2.1 Project Description

Flotation Energy, in conjunction with Vårgrønn, through Cenos Offshore Windfarm Limited ('The Company') are developing the Cenos Project, an offshore wind project of up to 1.4 GW capacity on the UK Continental Shelf. The aim of the project is to decarbonise existing oil and gas assets in the Central North Sea, saving up to 1,700,000 tonnes of CO_2 per year. The location of the wind farm area is shown in Figure 1.

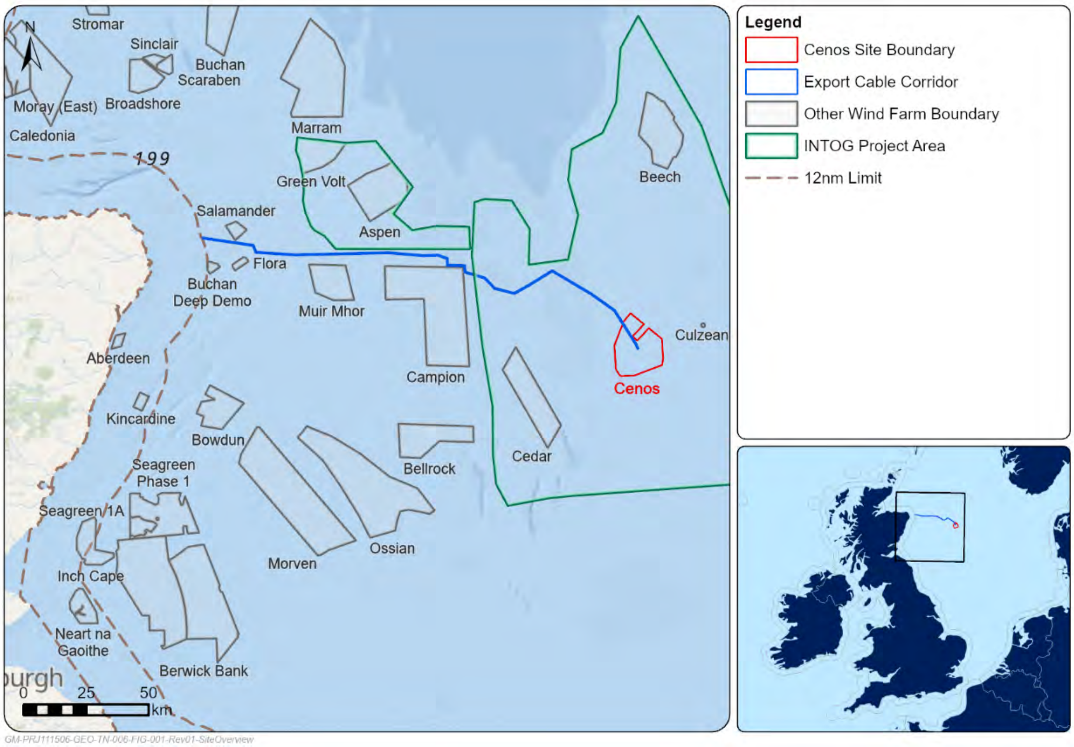


Figure 1: Location of Cenos Offshore Windfarm Project

2.2 Purpose of Report

The purpose of this report is to present the results of the CBRA and BAS completed by Global Maritime for the Cenos Inter-Array Cables. These studies have been conducted based on indicative cable routes developed as part of the CBRA and BAS study, developed in consultation with Cenos.

The following works have been completed and results detailed within this report for the entire lease area:

- Data review and gap analysis of all provided site data
- Review of the site conditions within the site boundary
- Cable Burial Risk Assessment (CBRA)
- Burial Assessment Study (BAS)

The cable routes developed as part of this report are based on an indicative turbine layout, and the CBRA results derived from this study have been used to provide an indication of the burial requirements for different parts of the site with regards to the soil conditions and distribution of vessel traffic. This indicative routing also provides an estimation for the number and total length of cables required, as well as crossings of the Culzean pipeline at the south of the site and associated remedial protection.

2.3 Abbreviations

Abbreviation	Description
AIS	Automatic Identification System
BSB	Below Sea Bed
BAS	Burial Assessment Study
CBRA	Cable Burial Risk Assessment
CFE	Controlled Flow Excavation
DOB	Depth of Burial
DOC	Depth of Cover
DOL	Depth of Lowering
DNV	Det Norske Veritas
DWT	Dead Weight Tonnage
ECR	Export Cable Route
ECC	Export Cable Corridor
GIS	Geographic Information System
GM	Global Maritime
GW	Gigawatts
IAC	Inter-Array Cable
ICPC	International Cable Protection Committee
KP	Kilometre Post
LA	Lease Area
LARS	Launch and Recovery System
LAT	Lowest Astronomical Tide
MBES	Multibeam Echosounder

Abbreviation	Description
mBSB	Metres Below SeaBed
MFE	Mass Flow Excavation
OSP	Offshore Platform
ROV	Remotely Operated Vehicle
RPL	Route Position List
SBP	Sub-Bottom Profiler
SRI	Subsea Rock Installation
SSBL	Stable SeaBed Level
SSS	Side Scan Sonar
TSV	Trenching Support Vessel
UHC	Ultimate Holding Capacity

Table 1: Abbreviations

2.4 Geodetic Parameters

The following geodetic parameters, unless specified otherwise, have been used throughout this report.

Reference	Description
Datum	WGS 1984
Projection	UTM Zone 31N
Vertical Reference	Lowest Astronomical Tide (LAT)

Table 2: Geodetic Parameters

2.5 Units

All distance and depth units within this report are measured in metres, unless stated otherwise.

Dates are given in dd/mm/yyyy format.

2.6 Cable Routing

For the extraction of CBRA results within the site boundary, the generation of a point-to-point layout was required. The aims of this routing exercise were to:

- Reduce total cable length.
- Eliminate crossings with the export route and the oil and gas connectors present within the site boundary.
- Minimise crossings with gas pipelines within the site boundary.

The turbine layout provided (L001) was amended by Global Maritime to relocate WTG 62 and WTG 73 from within the export cable corridor to within the Cenos windfarm boundary (L002). The routing exercise was performed on the L002 layout. The constraints and design parameters used in this routing exercise are shown in Table 3. Multiple iterations of route layouts were then created and compared until the most optimal straight-line route layouts were identified. The resulting cable route is referred to as C001 (Figure 2).

C001 is comprised of 17 strings; each of which is given a unique identifier and displayed in Figure 3. The total length of each string, with the number of WTGs per string, is displayed in Table 4.

Constraint	Hard Constraint Value
Internal Buffer of Cenos Wind Farm Boundary	25m
Distance from Wrecks	500m
Maximum Turbines per String	6

Table 3: Routing Constraints

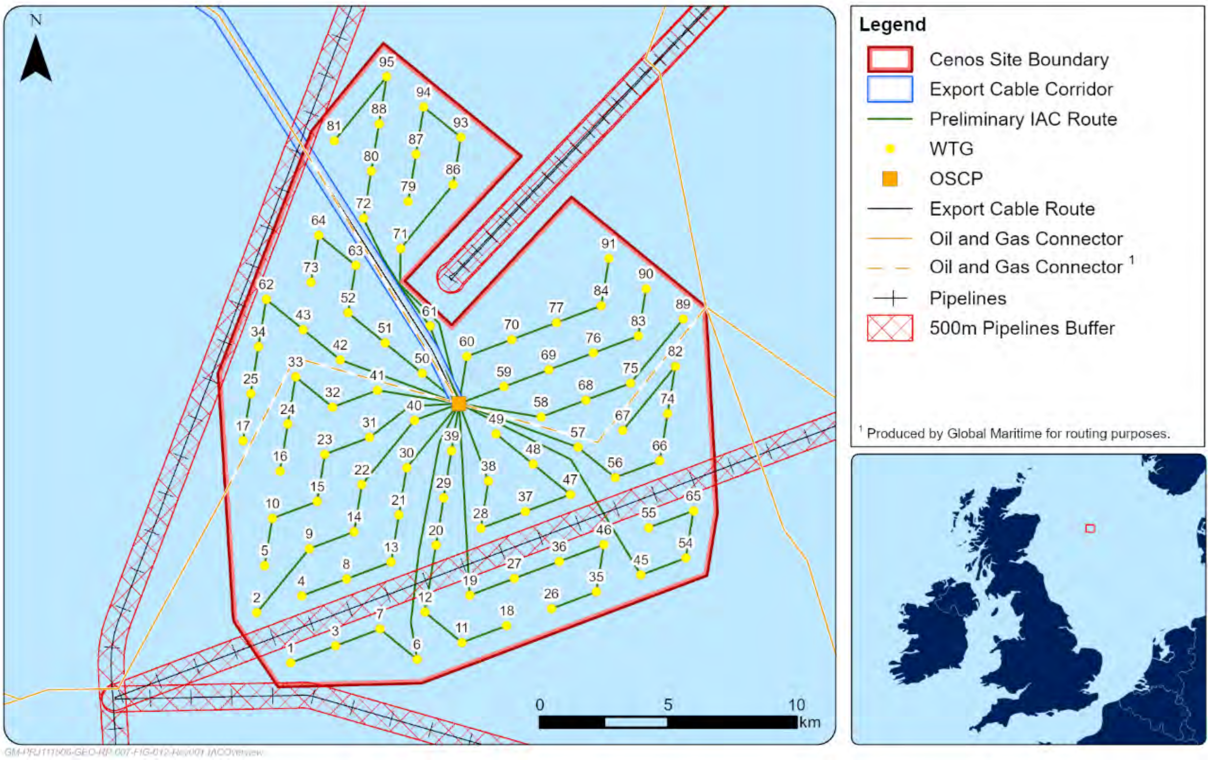


Figure 2: C001 Proposed Site Layout

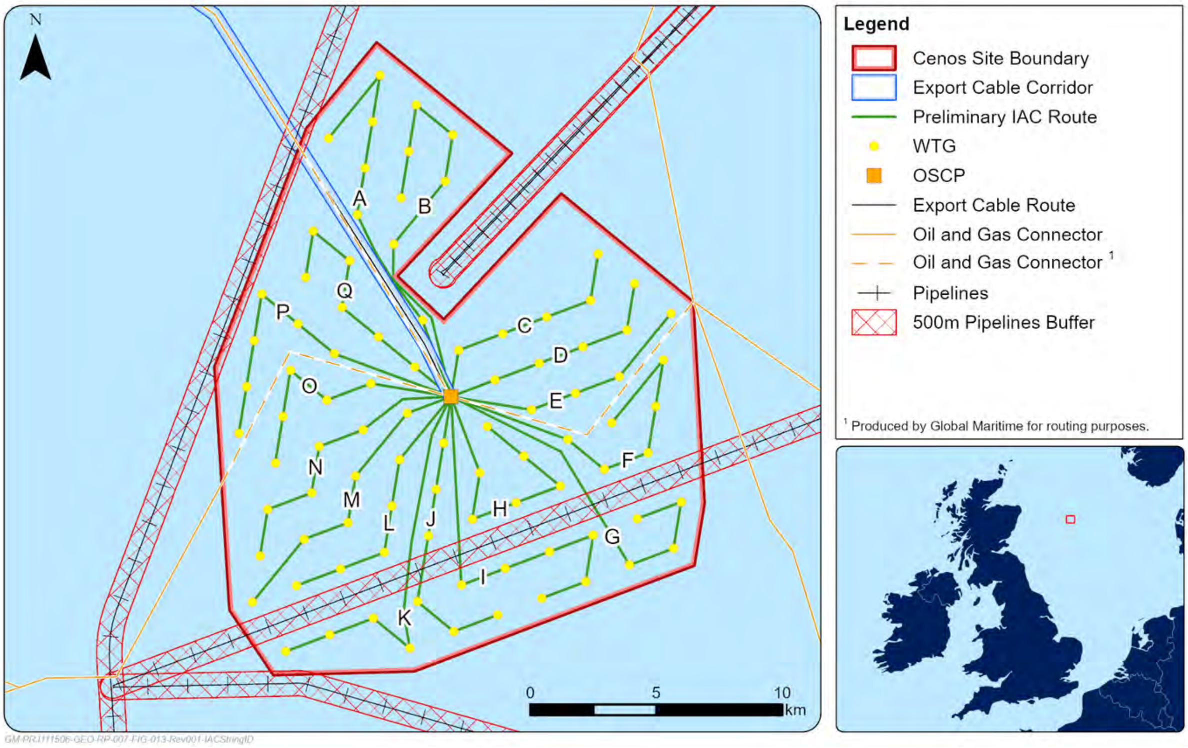


Figure 3: C001 String IDs

String ID	Number of WTGs per String	Total Length (km)
A	6	16.99
B	6	17.45
C	5	9.32
D	5	9.32
E	4	10.18
F	6	15.61
G	4	15.72
H	6	12.55
I	6	16.80
J	6	11.96
K	4	15.85
L	5	7.45
M	5	12.05
N	5	7.45
O	5	10.68
P	6	14.25
Q	6	11.18

Table 4: String Information

The layout does not cross the export cable route or the oil and gas connectors. Turbine 49 is located within the 500m buffer zone of an identified wreck (Survey Job Number: 23014) and therefore may require relocation to reduce risk. String H currently connects to Turbine 49 from the south and therefore only encroaches this 500m buffer by 150m (Figure 4).

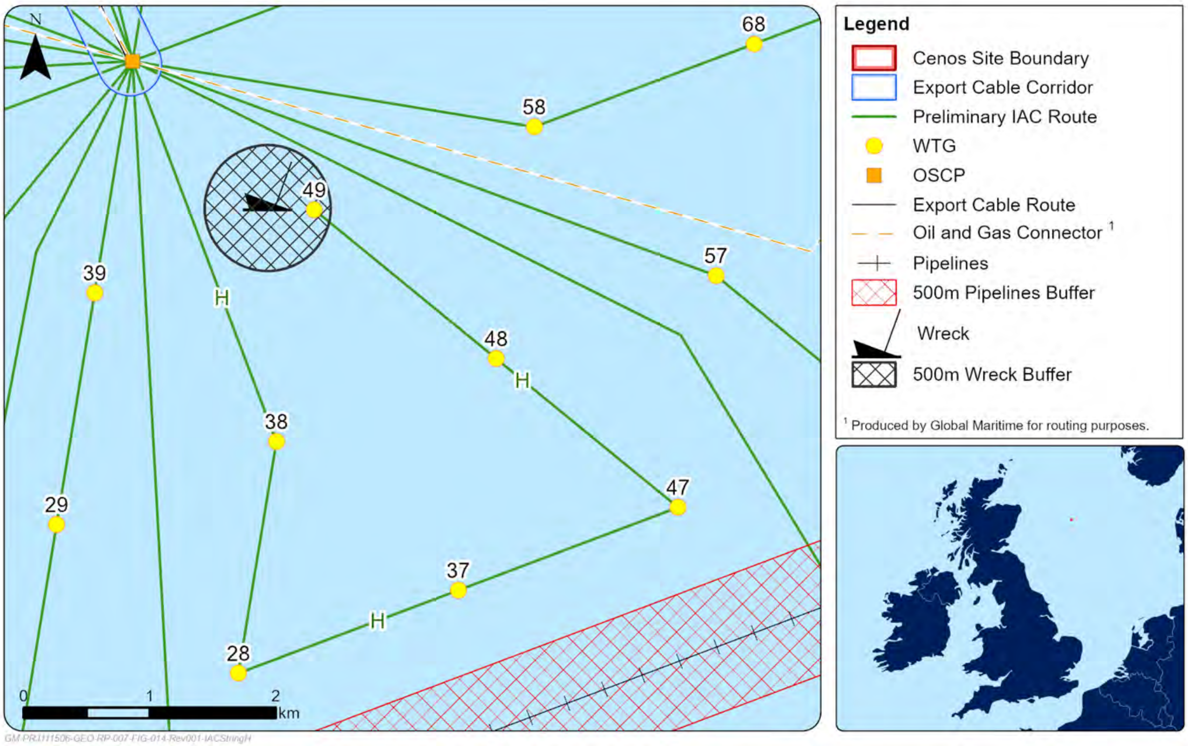


Figure 4: WTG 49

3. DATA REVIEW AND GAP ANALYSIS

3.1 Data Sources

The below project specific data have been used:

1) FLOCEN_BOSI_OWF_v00a_240313_emo_32631 (Cenos Windfarm Site Boundary)
2) FLOCEN_INAC_Route_L002_C001_v00a_240830_gbr_32631 (GM Preliminary Inter Array Cable Route)
3) SSDM_PR111506_Floatation_Cenus.gdb (2023 ROVCO Geophysical Survey Data)
4) FLOCEN_INEX_Route_v01_240524_emo_32631 (GM Preliminary Export Cable Route)
5) NSTA_Pipelines_Linear_WGS84_Z31N.shp (NSTA Offshore Infrastructure Pipelines Linear)
6) UKHO_Wrecks_WGS84_Z31N.shp (UKHO Wrecks and Obstructions Shapefiles)
7) 23014-EN-SU-RP-003 C1 OWF Geophysical Results Report
8) CEN001-GLM-01-CON-GPH-RPT-0001 Cenos Geological Desktop Study
9) GM-PRJ111506-GEO-TN-0007 Geotechnical Phase 1 Ground Investigation Locations in the Cenos ECC Area

The below external references have been used:

10) DNVGL, Recommended Practice, Subsea Power Cables in Shallow Water, Doc. No. DNVGL-RP-0360, March 2016
11) Cigre, Technical Brochure, Installation of Submarine Power Cables, Doc. No. TB883, October 2022.
12) DNV, Recommended Practice, Risk Assessment of Pipeline Protection, Doc. No. DNV-RP-F107, October 2010
13) Carbon Trust, Application Guide for the Specification of the Depth of Lowering using the Cable Burial Risk Assessment (CBRA) methodology, Dec 2015
14) Carbon Trust, Cable Burial Risk Assessment Methodology, Guidance for the Preparation of Cable Burial Depth of Lowering Specification, CTC835, February 2015
15) European Subsea Cables Association (2016), ESCA Guideline No. 6, The Proximity of Offshore Renewable Energy Installations & Submarine Cable Infrastructure in UK Waters, Issue 5, 10 March 2016
16) International Cable Protection Committee (2015), ICPC Recommendation No. 2, Recommended Routing and Reporting Criteria for Cables in Proximity to Others, Issue 11B, 3 November 2015
17) The Crown Estate (2012), Guideline for Leasing of Export Cable Routes/Corridors
18) BERR - Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry.

19) Navigation Safety Branch, Maritime & Coastguard Agency, Marine Guidance Note MCN543 (M+F) Section 3d, File Ref: MNA/053/010/0626, January 2016.

20) Ashley et al. (1990). Classification of large-scale subaqueous bedforms: a new look at an old problem. Journal of Sedimentary Petrology. 60. 160-172.

21) Digital Terrain Modelling: Principles and Theory. Li, Z., Zhu, Q. & Gold, C., 2005

22) Digital Elevation Model. Wiki.gis.com. Available at http://wiki.gis.com/wiki/index.php/Digital_Elevation_Model. Accessed 10th October 2022.

23) Everything you need to know about Digital Elevation Models (DEMs), Digital Surface Models (DSMs), and Digital Terrain Models (DTMs). Marwaha, N. & Duffy, E. Available at https://up42.com/blog/tech/everything-you-need-to-know-about-digital-elevation-models-dem-digital. Accessed 10th October 2022.

24) Discrete Differential Geometry: An Applied Introduction. Notices of the AMS, Communication. Crane K., 2018

25) Map Use: Reading, Analysis, Interpretation. Kimerling, A. et al, 2016. 7th Edition.

26) Cartigny, M.J., Postma, G., Van den Berg, J.H. and Mastbergen, D.R., 2011. A comparative study of sediment waves and cyclic steps based on geometries, internal structures and numerical modelling. Marine Geology, 280 (1-4), pp.40-56.

3.2 Data Review and Gap Analysis

To inform the routing, CBRA, and BAS, Global Maritime utilised the geophysical data pack from the ROVCO 2023 survey (Ref. 7). An adequacy review of the provided data for the purposes of this study is provided Table 5. Commentary and a traffic light assessment are also provided, representing **Adequate**, **Partially Adequate**, and **Inadequate**.

Data Type	Source	Comment	Adequacy
Project Boundary / RPL		Defined cable corridor and corresponding centreline. Cable routes and Turbine layout are GM's indicative cable routes developed for the CBRA.	Adequate
Bathymetry	(0, (7)	MBES with 100m linespacing with 2000m crossline spacing at 0.5m and 1.0m resolution.	Partially adequate
Shallow Geology	(0, (7)	SBP data at 8kHz and 0.1m vertical resolution, with 100m line spacing and 2000m crossline spacing. Consultation on seismic velocities and required penetration.	Partially adequate

Data Type	Source	Comment	Adequacy
Side Scan Sonar	(0, (7)	Dual frequency SSS data at 230kHz and 540kHz, with 0.3m and 0.2m resolution respectively. Target height from seabed estimated at ±20% accuracy. 100m line spacing with 2000m crossline spacing.	Partially adequate
Magnetometer	(0, (7)	Cycled at 10Hz and a survey speed of 4 knots, resulting in approx. 0.1m along track sampling resolution. Magnetometer was piggybacked on SSS and flown at a target height of 12.5m above seabed, meaning some targets may not have been detected. Positional accuracy is estimated to be ±3m, and discrepancies were corrected using SSS and MBES data. 100m line spacing with 2000m crossline spacing.	Partially adequate
Soil Provinces	(0, (7), (9)	Based on the geophysical survey data and ROVCO's interpretation, and re-interpreted by GM using publicly available data and GM's knowledge of the region	Adequate
Seabed features & targets	(0, (7)	Surficial targets are adequate in MBES and SSS data, though smaller targets may not be resolved due to resolution. Ferrous and buried targets may not be detected due to mag and SBP coverage.	Partially adequate
Geotechnical	N/A	No geotechnical data available. Soil geotechnical properties are inferred.	Inadequate

Table 5: Data Review and Gap Analysis

Several of the data sources in Table 5 are listed as Partially adequate, which is primarily driven by the coverage achieved (i.e. approximately 85% coverage of the MBES and SSS data during the 2023 Rovco geophysical survey (Ref. 7). For the areas covered by the survey, the data is adequate, however as there are gaps in data coverage across the site, these 'no data' areas must be regarded as inadequate. Therefore, the overall assessment has been deemed partially adequate.

Areas with no data coverage in the MBES and SBP have been extrapolated to provide sufficient coverage for development of the ground model. These areas are therefore a 'best estimate' of the seabed conditions based on the surrounding data, and therefore will not resolve more localised geohazards. They still however enable general site characterisation and production of the CBRA model, and subsequent recommendations on cable installation and protection methodology.

4. SITE CONDITIONS

4.1 Bathymetry

The minimum water depth across the site is 82m, with the maximum depth reaching 105m below LAT. The site is generally very flat, with an average gradient of <1°. The seabed very gently slopes from the northwestern corner of the site towards the southeastern corner, with a relatively shallower area towards the middle.

Some areas of the site have not been covered during geophysical survey, due to termination of the survey prior to its completion. Approximately 85% coverage has been achieved. Larger bathymetric features have been extrapolated across these gaps where the data allowed adequate interpolation, but smaller features in these areas are not covered.

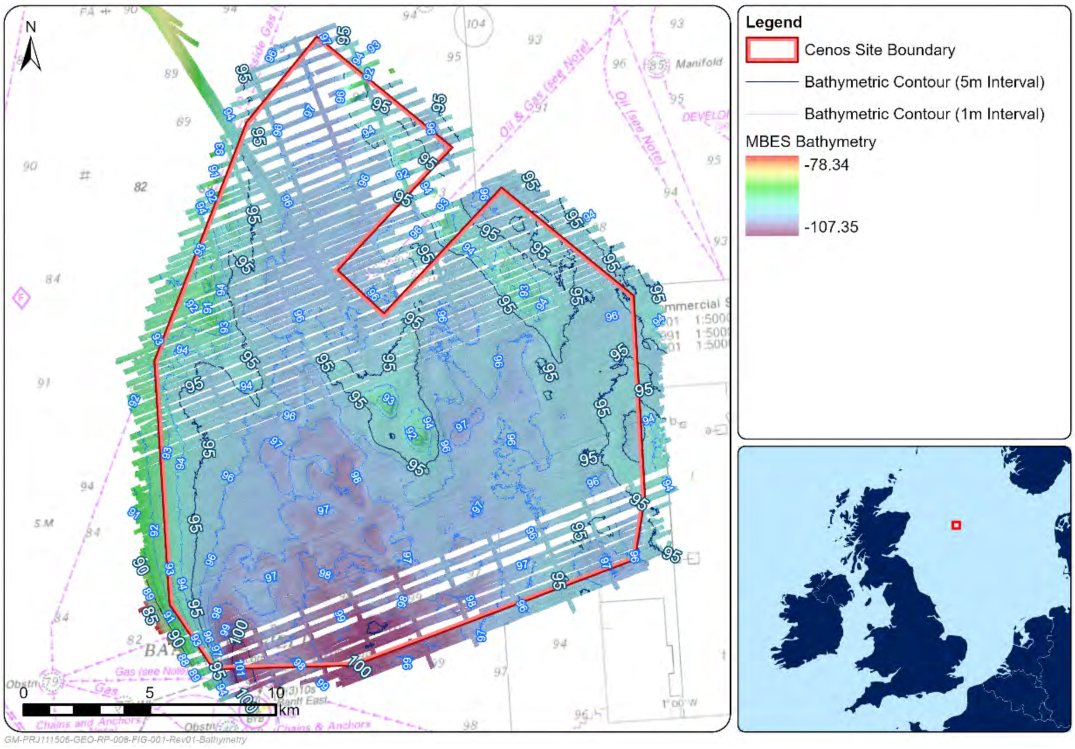


Figure 5: Bathymetry

4.2 Local Geology

The Cenos project is located in the central North Sea, situated in The Graben, with the ECC crossing several other areas of the North Sea basin. The basin originated during episodic extensional rifting from the Palaeozoic to the early Cretaceous, followed by continuous subsidence throughout the late Cretaceous and Cenozoic, and basin inversions during the Paleogene.

The region is characterised by the formation of hydrocarbon deposits in the Jurassic and Tertiary, and glacial and interglacial cycles during the Quaternary. During the latter, an extensive shallow marine environment was created, and fluvial-deltaic and glacial sediments were deposited. During the Pleistocene, marine conditions (including further sediment deposition) were succeeded by glacial sedimentation and regional erosion, and further sediments were deposited during glacial retreat during the Holocene.

A detailed description of the regional geological history can be found in GM's Geological Desk Top Study.

4.3 Boulders

Boulders pose a risk to cable installations for multiple reasons: they can affect cable lay where free spanning can happen, cause faults over time as a result of movement and fatigue, and hinder trenching tools' ability to bury the cable sufficiently. Therefore, boulders should be avoided; however, even if the cable avoids boulders at the seabed, boulders at the surface still need to be avoided to avoid collisions with burial tools. In areas of sparse boulders, this can be achieved by cable routing alone, however in areas with dense boulders, some must be cleared to make way for cable installation.

Boulders can be cleared using a variety of methods, as detailed in section 6.6.4. The lease area contains a large number of boulders, distributed across the entire site with particularly high density in the north and east. The size distribution was calculated for the lease area boulders, the results of which are shown in Table 6 and Figure 6, and also displayed spatially in Figure 7.

Of the boulders identified in the lease area survey data, the majority can be moved by either a plough or grab. There are however a substantial number that will need to be avoided by the cable routes. At the time of writing, the inter-array cable routing is not yet completed. Once routing is complete, a listing of boulders that will need clearing can be generated.

It should be noted that the vast majority of boulders of >3m appear to occur below an apparent line across the middle of the lease area. The survey report (Ref. 7) indicates that this line is associated with survey blocks A and B, and survey blocks C and D have not had the same boulder interpretation method applied (i.e the size difference may be an artefact from interpretation). Therefore, there is a possibility that further boulders of >3m in size may be present within survey blocks C and D. Simailarly, there are gaps in the MBES and SSS coverage where boulders (and other objects) will not have been detected.

Boulder Count	7,523
Mean Size (m)	3.03
Standard Deviation of Boulder Size (m)	5.86
Minimum Size (m)	0.32
P - 25% Size (m)	1.1
P - 50% Size (m)	1.6

P - 75% Size (m)	2.73

Table 6: Statistics of Boulders present in the lease area

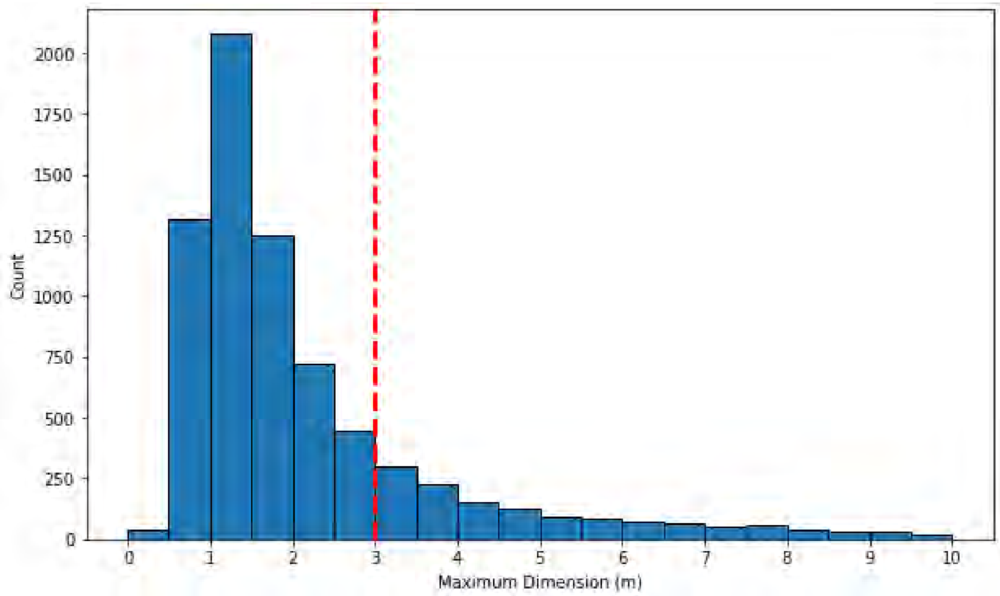


Figure 6: Size distribution of the boulders within the lease area

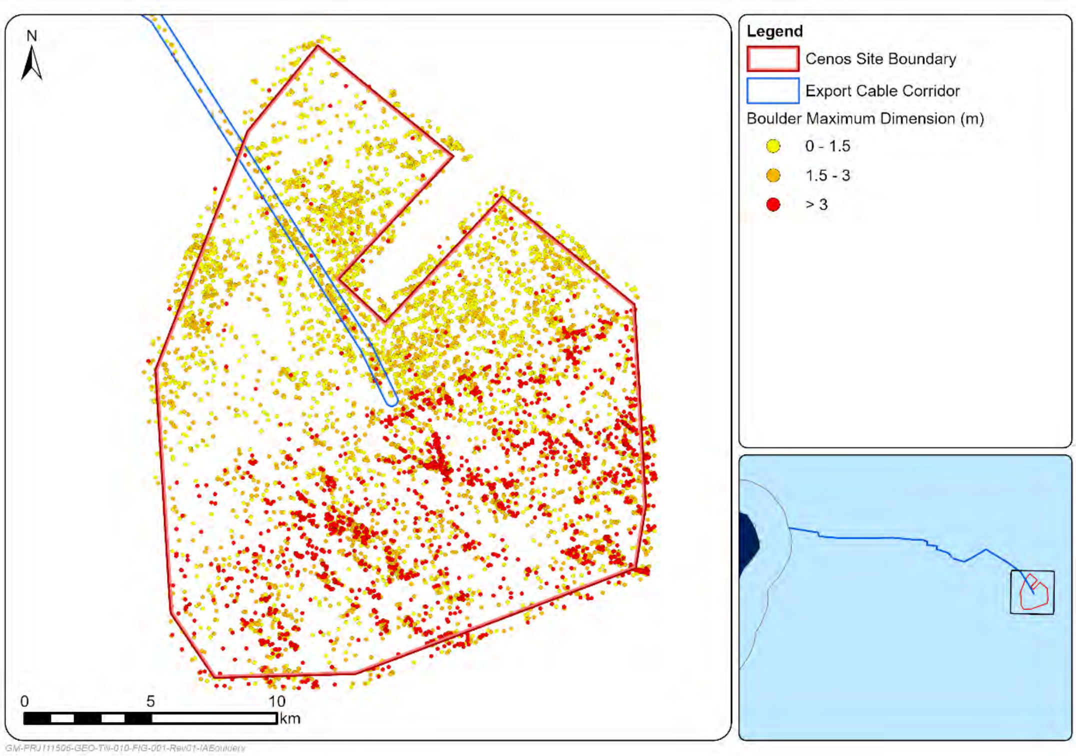


Figure 7: Spatial and size distribution of the boulders in the lease area

4.4 Ground Model

From GM's knowledge of the regional geology and review of publicly available data and literature, a preliminary ground model of the ECC was developed using seismic survey data collected by ROVCO in 2023 (ref. 7). The production of the ground model is detailed in the Preliminary Ground Model Report and is summarised below.

The acoustic horizons defined by ROVCO correspond to geological units and formations that are documented in the region. Based on published literature, GM has inferred the physical properties of these units, as described in the Geotechnical Ground Investigation Locations Report (ref. 9).

Epoch	Lithostratigraphic Unit	Expected Lithology	Undrained Shear Strength (kPa)	Moisture Content (%)	Plasticity Index (%)	Bulk Density (Mgm^{-3})
Holocene	Forth Formation	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	<50	11-40	15-30	1.8-2.2
Pleistocene	Coal Pit Formation	Silty clay with occasional pebbles; some sand laminae	20-150	20-30	20-40	1.8-2.3
	Fisher Formation	Silty clay overconsolidated; sand intercalations	75-150	15-25	20-30	2.0-2.2
	Ling Bank Formation	Fine sand and mud	>150	15-45	12-50	1.8-2.2
	Aberdeen Ground Formation	Clay with sand layers; consolidated to overconsolidated	>500	5-30	5-30	1.9-2.4

Table 7: Anticipated geological units and inferred geotechnical parameters

4.5 CBRA Ground Model

GM's 3D CBRA modelling method uses a two-layer ground model, with defined units assigned to each layer based on the undrained shear strength (expressed in kPa) and relative density values of the actual soils. This approach is used to simplify the model production, without compromising the results of the CBRA. The model units are assigned based on the units identified from geophysical and geotechnical survey (or in this case inferred from the geophysical data), and the geophysical horizons used to define the boundary between the upper and lower layer of the model.

Unit Code	Soil Description	Su From (kPa)	Su To (kPa)	Dr From	Dr To
S1	Loose SAND	n/a	n/a	0%	35%
S2	Medium dense SAND	n/a	n/a	36%	65%
S3	Dense SAND	n/a	n/a	66%	100%
C1a	Extremely low strength CLAY	1	5	n/a	n/a
C1b	Extremely low strength CLAY	5	10	n/a	n/a
C2	Very low strength CLAY	10	20	n/a	n/a
C3	Low strength CLAY	20	40	n/a	n/a
C4	Medium strength CLAY	40	75	n/a	n/a
C5	High strength CLAY	75	150	n/a	n/a
C6	Very high strength CLAY	150	300	n/a	n/a
C7	Extremely high strength CLAY	300	1000	n/a	n/a

Table 8: GM CBRA ground model unit codes

Using the ground model described in section 4.4, the two-layer CBRA model was developed for the ECC. The units inferred from the ground model in Table 7 were assigned the CBRA units codes as follows:

GM Ground Model			CBRA Two-Layer Ground Model			
Epoch	**Lithostratigraphic Unit**	**Expected Lithology**	**Base Seismic Horizon**	**Unit Code**	**Su From (kPa)**	**Su To (kPa)**
Holocene	Surficial Sediment	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders*	N/A	S1	N/A	N/A
	Forth Formation	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	H10 / H15	C1b	5	10
Pleistocene	Coal Pit Formation	Silty clay with occasional pebbles; some sand laminae	N/A	C6	150	300
	Fisher Formation	Silty clay overconsolidated; sand intercalations	GM_H16 / GM_H17 / GM_H18	N/A	N/A	N/A
	Ling Bank Formation	Fine sand and mud	H40	N/A	N/A	N/A
	Aberdeen Ground Formation	Clay with sand layers; consolidated to overconsolidated	N/A	N/A	N/A	N/A

Table 9: GM Ground Model and conversion to CBRA model units (*Derived from ROVCO survey report)

Only three units have been derived for the CBRA ground model. The other units inferred by GM from the geophysical survey data are beyond the depth of interest for cable burial, and more relevant for OSP foundation design and anchor piling. Using the seismic horizons, the spatial distribution and vertical extent of each unit across the two layers in the CBRA model has been determined, as shown in Figure 8, Figure 9 and Figure 10.

The vast majority of the site is covered by surficial Holocene sands, with cobbles and boulders throughout. The small section designated as C1b in layer one corresponds to outcropping low strength silty sands and clays associated with the Forth formation. In layer two, the majority has been designated as C1b, as a continuation of the Forth Formation units, with some areas in the eastern side of the site designated C6, corresponding with the Coal Pit formation.

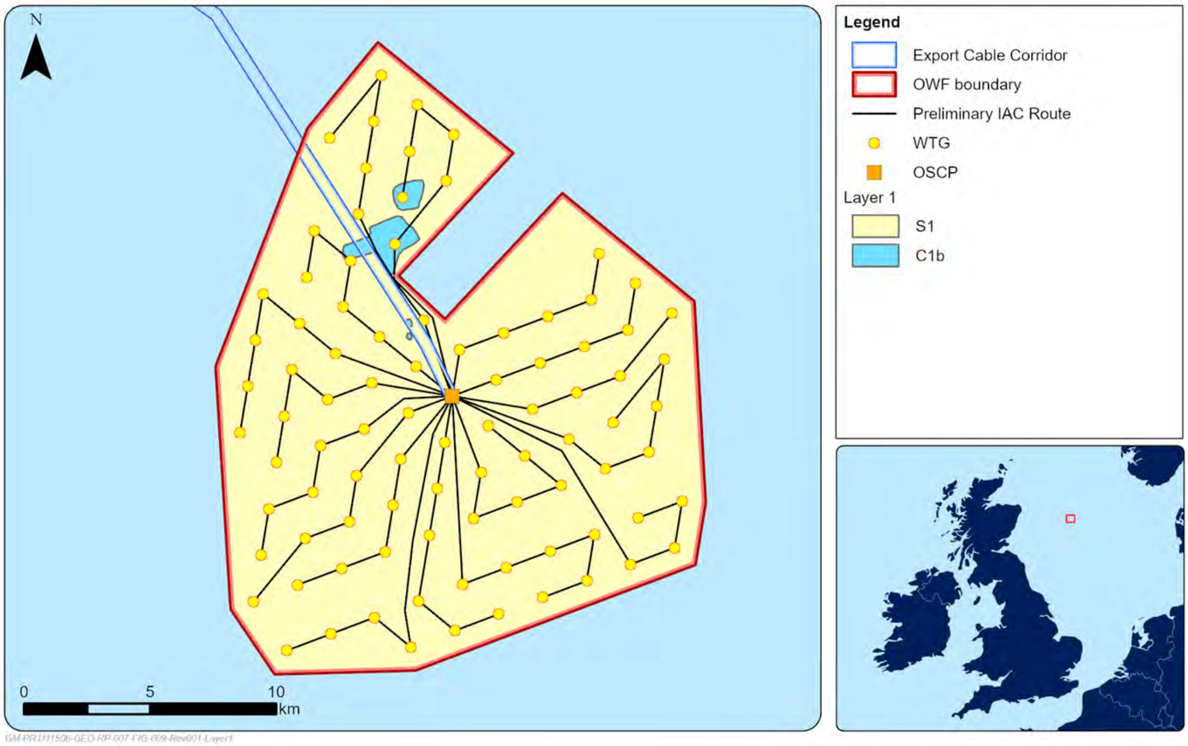


Figure 8: Layer 1 of the GM CBRA Ground Model

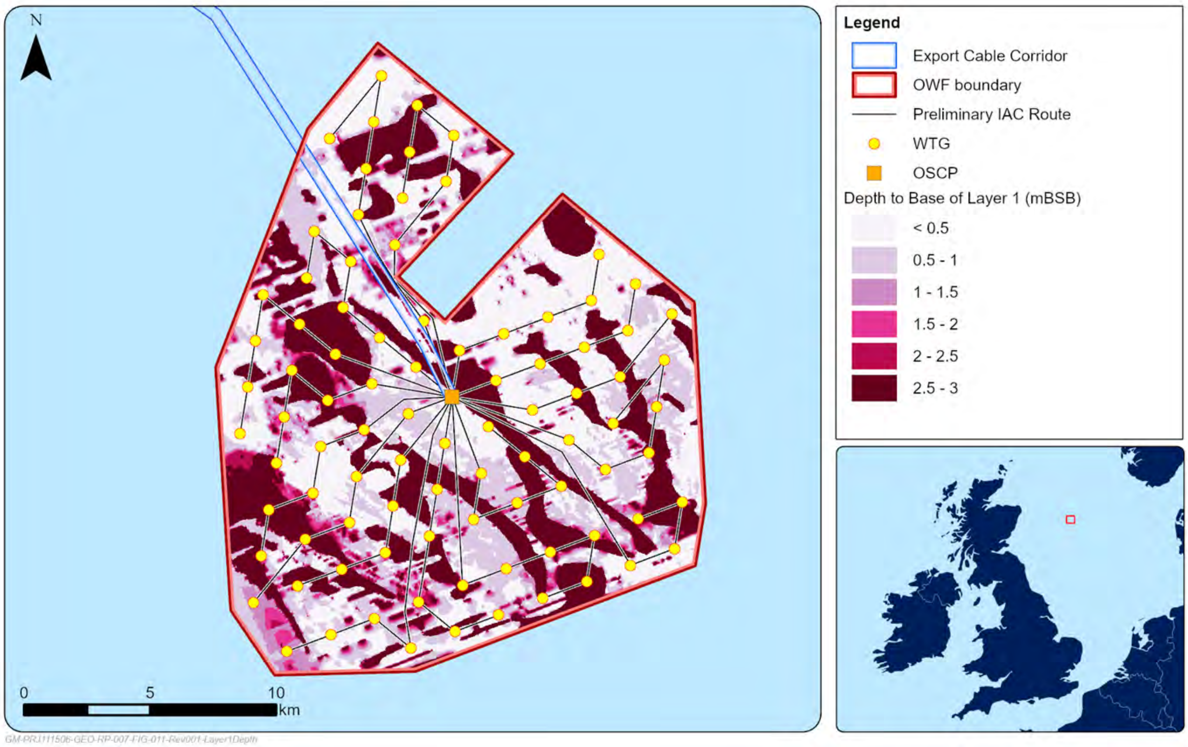


Figure 9: Depth of Layer 1 of the GM CBRA Ground Model

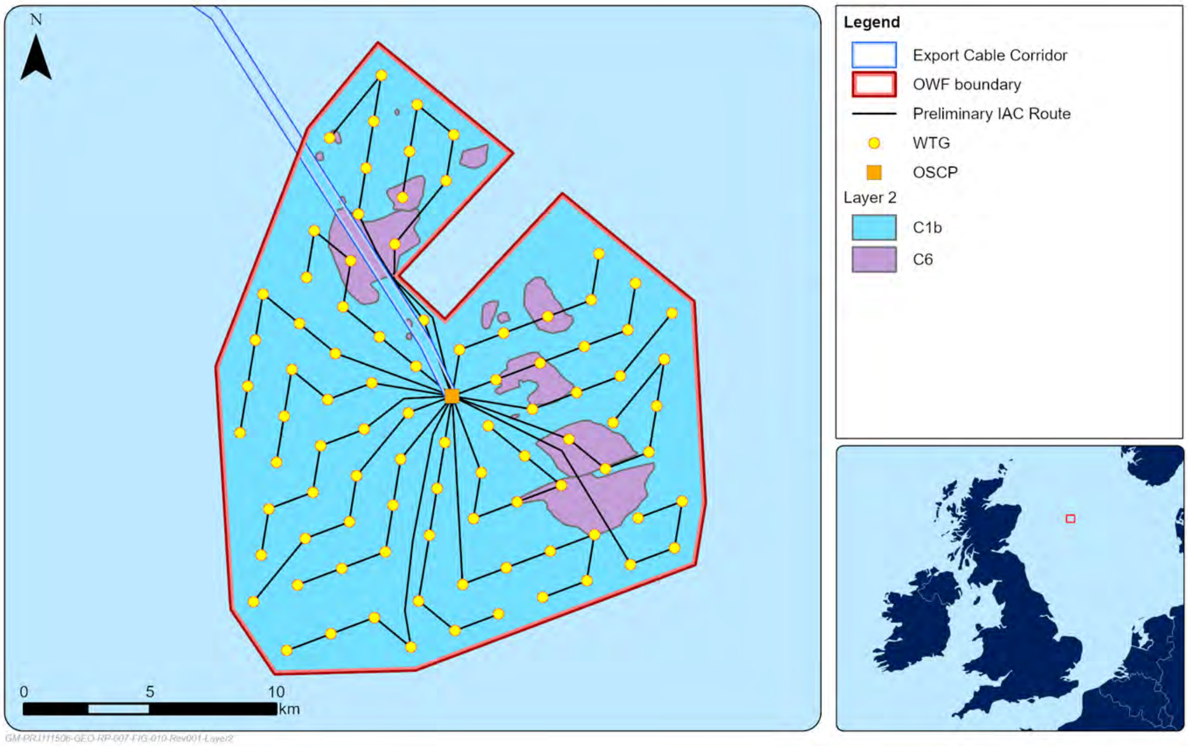


Figure 10: Layer 2 of the GM CBRA Ground Model

4.6 Stable Seabed Level

4.6.1 Terminology

Digital Elevation Models, Digital Terrain Models and Digital Surface Models

A Stable Seabed Level (SSBL) is a form of Digital Elevation Model (DEM), which are in turn defined as "a digital representation of ground surface topography or terrain". While the term DEM can be used for any representation of terrain as geospatial data, it is generally restricted to the use of a regular grid of elevation values (Ref. 21).

DEMs can be further split into two distinct categories, both of which are applicable to development of a SSBL. Firstly, Digital Surface Models (DSM) are used to represent the earth's surface including all objects on it. In a marine environment these surface features may include the anthropogenic (wrecks, pipelines) or those related to the natural, physical environment (bedforms, boulders). A DSM captures both natural and human-made features of the environment. Digital Terrain Models (DTM) represent the underlying "bare-earth" terrain, such as channels and ridges, after surface features have been removed.

In the case of SSBL the input bathymetric grid (inclusive of bedforms) can be considered a DSM. The final output SSBL, with bedforms removed, is a DTM.

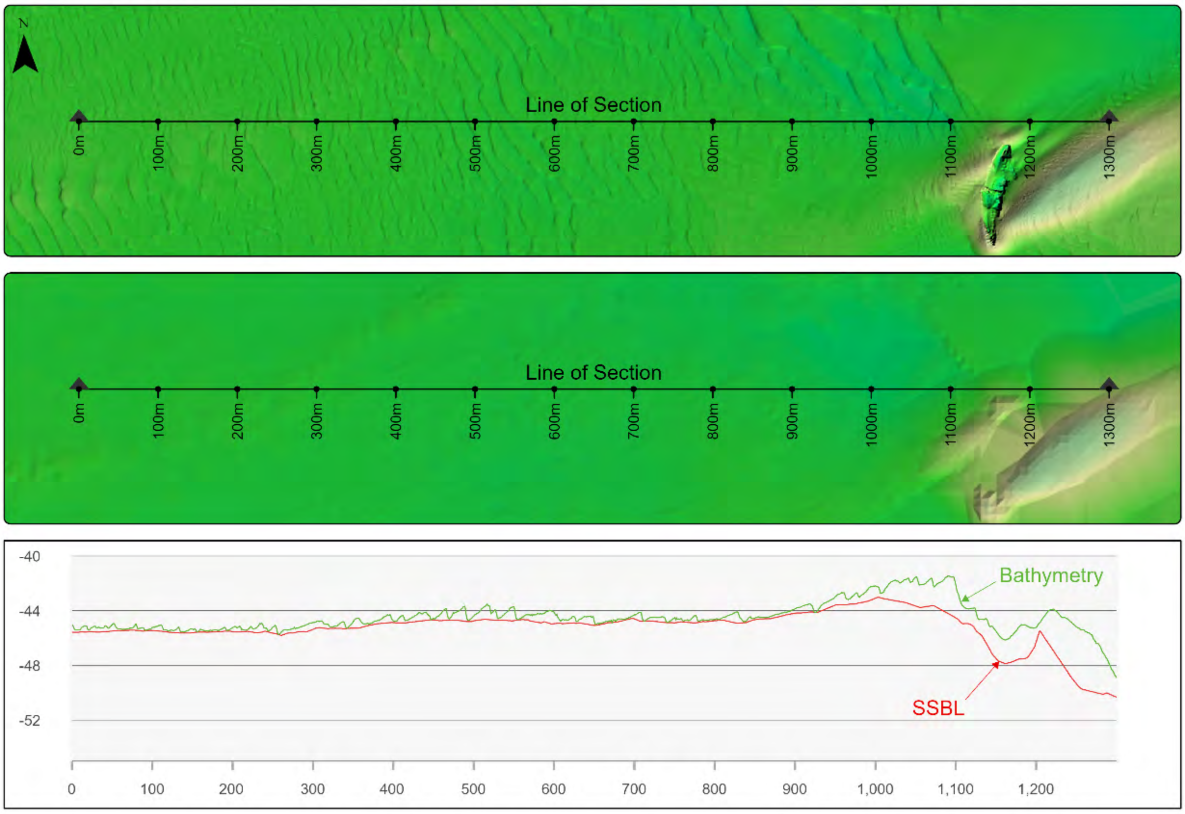


Figure 11: Comparison of seabed (DSM) and SSBL (DTM) surfaces - example for illustration of method only

Stable Seabed Level

A SSBL is a form of DTM, which aims to determine a base of mobile seabed sediments. In its most comprehensive form, an SSBL will factor in temporally disparate, repeat bathymetric surveys, along with long-term morphodynamical modelling, to produce a surface below which seabed will not fall below for the lifetime of the project.

This SSBL is based on a single bathymetric dataset collected in 2023 (Ref. 7). The SSBL output from this workflow therefore represents a snapshot only, based on available bathymetric data, and does not account for forward modelling at this stage. The resultant SSBL should therefore be considered an indicative level, below which seabed geology is unlikely to be impacted by short- or medium-term seabed mobility.

From this model it is possible to identify features which fit a general profile expected in mobile features; however, it is not possible to confirm the rates or directions of migration for any of the features identified. It is also possible that the current SSBL is exceeded by future events. Accuracy and confidence can be improved by incorporating in additional bathymetric surveys; and by integrating full project lifecycle morphodynamical modelling.

4.6.2 Methodology

Area of Study

The primary aim of this study is to identify the stable seabed level across the lease area, and it is along these routes that the charting and reporting focuses. The result is a SSBL surface with full coverage within the extent of the input bathymetric grid.

Aggregation of Bathymetry

In the case of Cenos, the SSBL is derived from a single, 0.5m resolution mosaicked bathymetric surface. The resolution of input bathymetry is aggregated to 10m resolution, retaining only the lowest value in each 10x10m cell. Reducing resolution through aggregation allows for identification of only small or medium features. Retaining only the lowest value ensures the resultant SSBL surface will never intersect above the original input bathymetry.

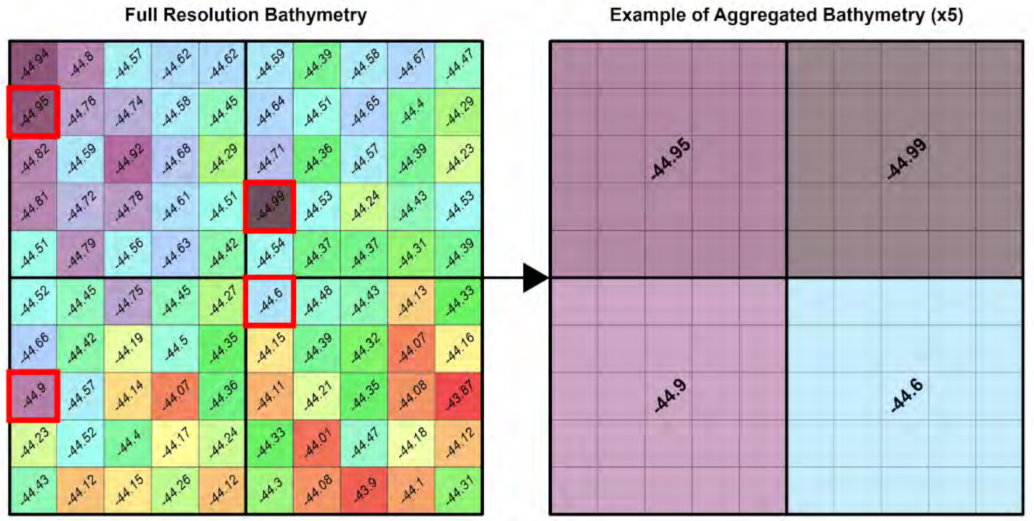


Figure 12: Aggregation based on the lowest value

Identification and Removal of Convex Seabed

The aggregated surface is reclassified into areas of convex and concave seabed based on its curvature. Geometric curvature finds the best fitting (osculating) circle to approximate the shape of a curve at any point. The curvature is the reciprocal of the radius of that circle (1/r). A straighter line will be best fit with a larger circle resulting in a smaller curvature, and tighter curved line will be best fit with a smaller circle resulting in a larger curvature (Ref. 26).

Profile curvature affects the acceleration or deceleration of flow across the surface (Ref. 24) and can be visualised as the shape of a profile cross section through the surface (Figure 13). A negative value indicates that the surface is upwardly convex at that cell. A positive profile indicates that the surface is upwardly concave at that cell. A value of zero indicates that the surface is linear.

Profile (normal slope line) curvature is calculated parallel to the direction of the maximum slope within a given neighbourhood, measuring the geometric normal curvature along the slope line. This curvature is typically applied to characterise the acceleration and deceleration of flow down the surface by force of gravity. At higher velocity, water can carry and move larger amounts of material; areas of acceleration become areas of erosion and areas of deceleration become areas of deposition. Profile curvature is therefore considered the most appropriate method to identify bedforms (Ref. 14), (Ref. 23).

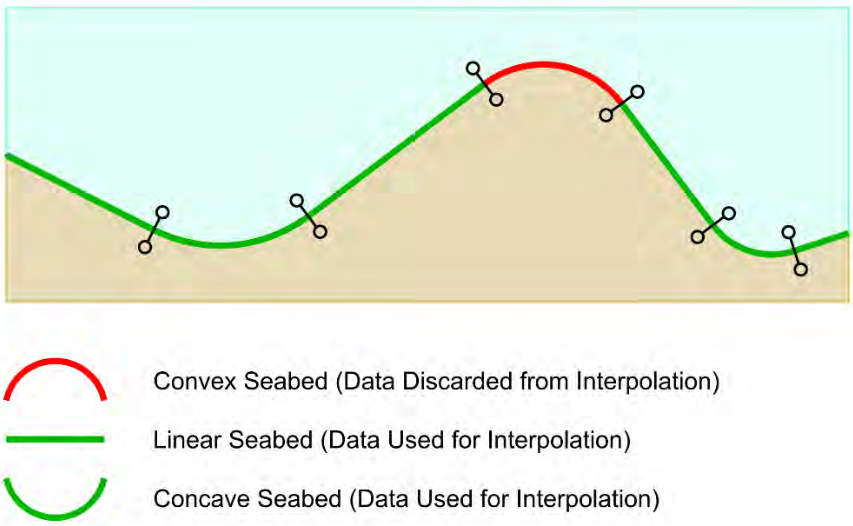


Figure 13: Curvature Radius

<u>Interpolation</u>

Convex areas are removed from the model, retaining only the 10m aggregated lowest points of the seabed between bedforms. The gaps between bedforms are interpolated using Delaunay triangulation, resulting in a continuous surface lowered below bedforms.

4.6.3 Results

The methodology described in Section 4.6.2 results in two gridded surfaces: one representing the SSBL; and another representing bedform heights, which is calculated by subtracting the original input bathymetry from the SSBL. The SSBL uses the original bathymetry in areas of non-crystalline bedrock, till, and clay, which are considered stable surficial sediments.

Due to the gaps in data coverage across the lease area, the SSBL results were limited in their use. This is due to the gaps being exaggerated by the aggregation of the bathymetry DSM. A general assessment of mobile features was conducted from the geophysical survey data, which indicated that the few mobile features on the site are of a scale that can be simply mitigated by burial of the cable. The depth of the site, and general lack of prevailing tidal currents at seabed means that seabed mobility is minimal.

5. CABLE BURIAL RISK ASSESSMENT

5.1 CBRA Methodology

5.1.1 Risk Assessment Methodology

There are a wide range of obstacles and seabed users that present potential hazards to subsea cables; or which have direct interactions with cables that risk damage. Such hazards include ship anchors, which could impact or snag the cable if dragged along the seabed; and fishing, where bottom trawling gear can snag and damage cables. The aim of this study is to evaluate potential risks to the cable and provide recommendations as to the most efficient risk mitigation, including recommendations of burial depth where appropriate.

The basis of a risk assessment for a submarine cable relies on identifying the potential hazards, associated risks, and evaluating the level of protection that may be afforded to the cable by its armouring (internal and/or external), cable burial beneath the seabed or any other means, such as rock dumping or concrete mattressing.

The most reliable and cost-effective form of cable protection is generally recognised to be ensuring no interaction between the cable and the identified hazards. This is most easily achieved by routing the cable away from such hazards or, where this is not practical, by burial below the seabed.

The simplified methodology followed in this report is adopted in accordance with the industry guidance documents:

- Carbon Trust, Cable Burial Risk Assessment (CBRA) Methodology (Ref. 14)
- Carbon Trust, CBRA Application Guide (Ref. 13)
- DNV-GL Subsea Power Cables in Shallow Water (Ref. 12)

The methodology for the CBRA includes an assessment of the seabed conditions followed by the identification and quantitative assessment of the threats/hazards for the area. A probabilistic assessment has then been performed using Global Maritime's in house GIS based software to assess the risk posed to the cable by external threats and a recommended burial depth has been established. This includes a full 3-dimensional approach to the probabilistic calculation of the threat of an anchor strike.

The CBRA method reviews an identified hazard based on its anticipated frequency and consequence. The combined outcome of frequency and consequence indicates whether risk is unacceptable, 'As Low As Reasonably Practical' (ALARP) or Acceptable. This adheres to the criteria outlined in DNVGL-RP-F107 (Ref. 12). The risk matrix used, and definitions of probability and severity are shown in the below tables.

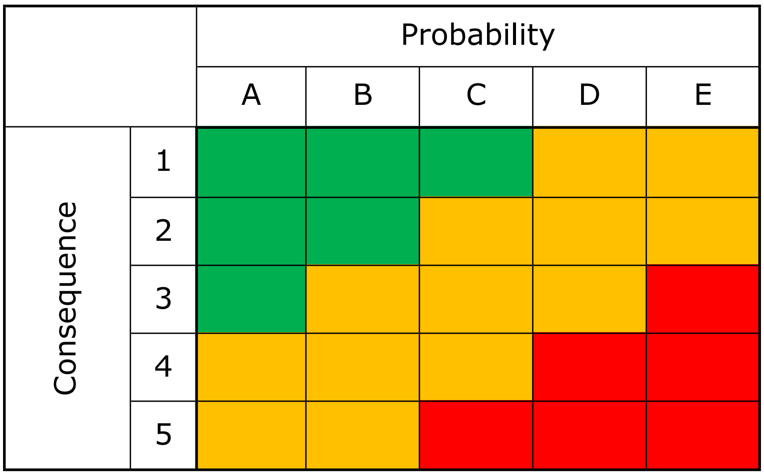


Table 10: Risk Matrix

Probability	Definition
A (Very Unlikely)	Never Heard of in Industry
B (Unlikely)	Heard of in Industry
C (Possible)	Incident has been known to occur, but rarely
D (Likely)	Happens several times a year in Industry
E (Very Likely)	Happens several times a year at project location

Table 11: Probability Definitions

Consequence	Definition
1	Negligible Damage
2	Minor Damage / Exposure to other hazards
3	Localised Damage / No unplanned loss of capacity
4	Major Damage - replacement of small section / Unplanned loss of capacity
5	Extensive Damage - replacement of significant section of cable/ Significant unplanned loss of capacity

Table 12: Consequence Definitions

5.1.2 Hazard Classification

Hazards are classified as primary or secondary. Primary hazards are those that have a direct impact upon the cable and can cause damage and secondary hazards are those that do not damage the cable directly but can result in increased risk or susceptibility to damage from primary hazards.

An example of a primary hazard would be impact or snagging of the cable due to a ships anchor being deployed. An example of a secondary hazard would be seabed mobility resulting in reduced cable burial cover or exposure, leaving the cable vulnerable to primary hazards.

5.1.3 Cable Burial – Carbon Trust Terminology

As presented in the methodology above, threat lines have been suggested for the identified site hazards for cable burial (sections 5.2 and 5.3). These follow the information and terminology described in the Carbon Trust Guidance Documents (Ref. 13). Figure 14 provides an illustration and summary of the main abbreviations and terminology used for burial in this report. The Target DOL generally includes an installation tolerance (or safety allowance).

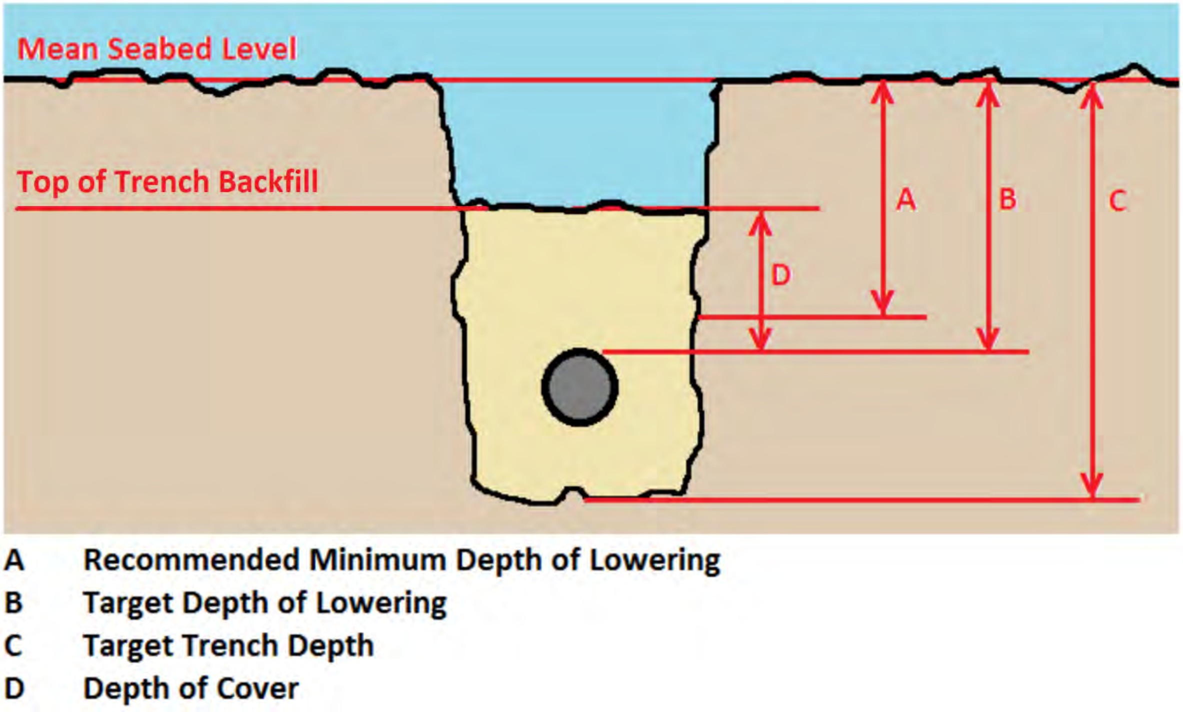


Figure 14: Definition of trench parameters and abbreviations

5.2 Hazard Identification and Assessment

5.2.1 Introduction and Risk Register

Data supplied and acquired from third parties has been assessed to develop a risk register (Appendix A) which has been compiled using probability and severity classification to evaluate the potential risks to cables across the site for both installation phases and the operational lifetime of the wind farm. The purpose of this exercise is to ensure that all hazards are identified and assessed and the risk to cables appropriately acknowledged, with initial indications on mitigations presented where possible. The main hazards identified in the risk register are discussed in more detail below.

The Risk Register is considered a live document which is to be updated throughout the life of the project and should be reviewed frequently.

5.2.2 Primary Hazards

5.2.2.1 Shipping Activity

Shipping is generally the most onerous anthropogenic risk to cables in terms of threat line depth (even if not the most likely to occur). The main hazard associated with shipping is the deployment of an anchor in proximity to a cable leading to anchor strike. Anchor strike does not necessarily lead to cable damage though it is likely to occur if a cable is inadequately protected through burial to an appropriate depth. The risk of this hazard is associated with the type of vessel traffic, its density, and the frequency of transit in proximity to the cable or cables. The vessel traffic density for August 2022 to August 2024 is shown for all vessel categories and sizes in Figure 15.

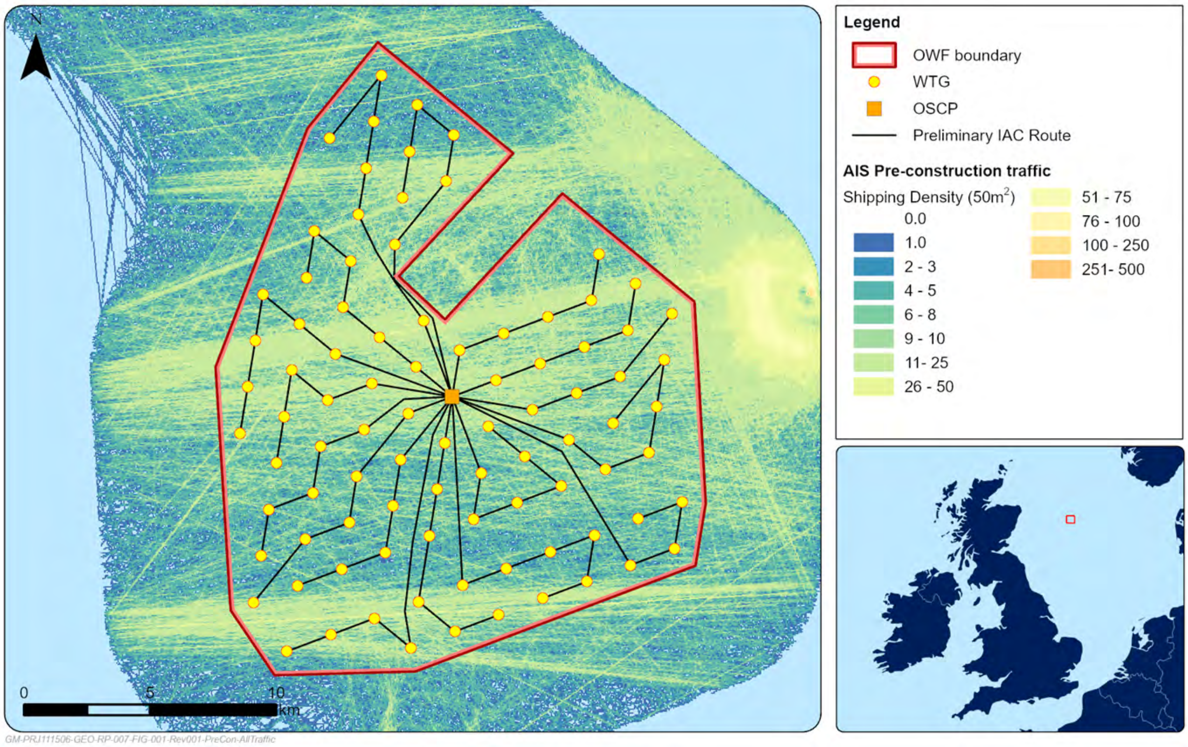


Figure 15: Pre-Construction Vessel Traffic

The hazard to subsea cables from shipping is associated with the deployment of anchors either in designated anchorage zones (which should be avoided through routing) or in emergency situations that result in anchor deployment through mechanical failure or deployment without due care. The potential impact on the seabed and/or the resultant snagging of a deployed anchor can result in damage to a buried cable.

Traffic across the lease area appears to be largely associated with the nearby Oil and Gas assets and crosses the site from east to west or west to east. There are two main 'lanes' of traffic crossing the site towards the middle and south, with a smaller lane crossing in the northern part of the site.

The marine traffic data can be further analysed and categorised into various vessel categories as follows:

- Cargo / Tanker Vessels
- Fishing Vessels
- Government Vessels
- Offshore Industry Vessels
- Passenger / Pleasure Vessels
- Port / Dredging Vessels

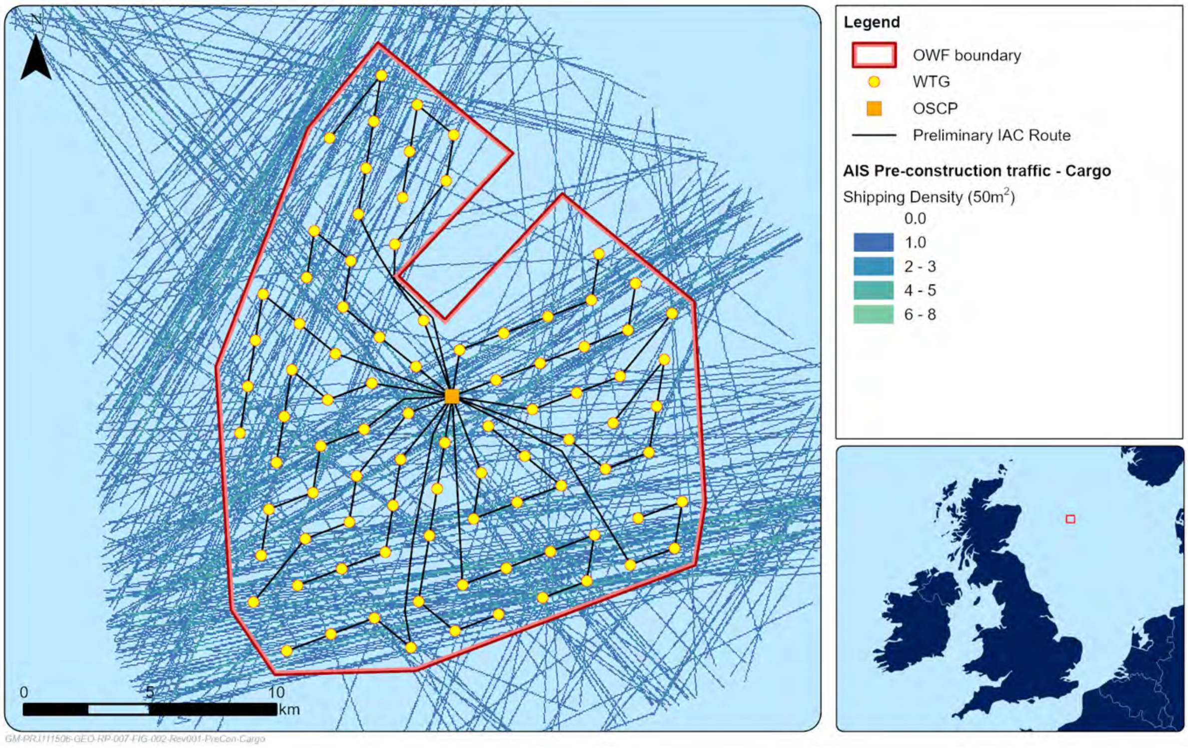


Figure 16: Pre-Construction Cargo Vessel Traffic

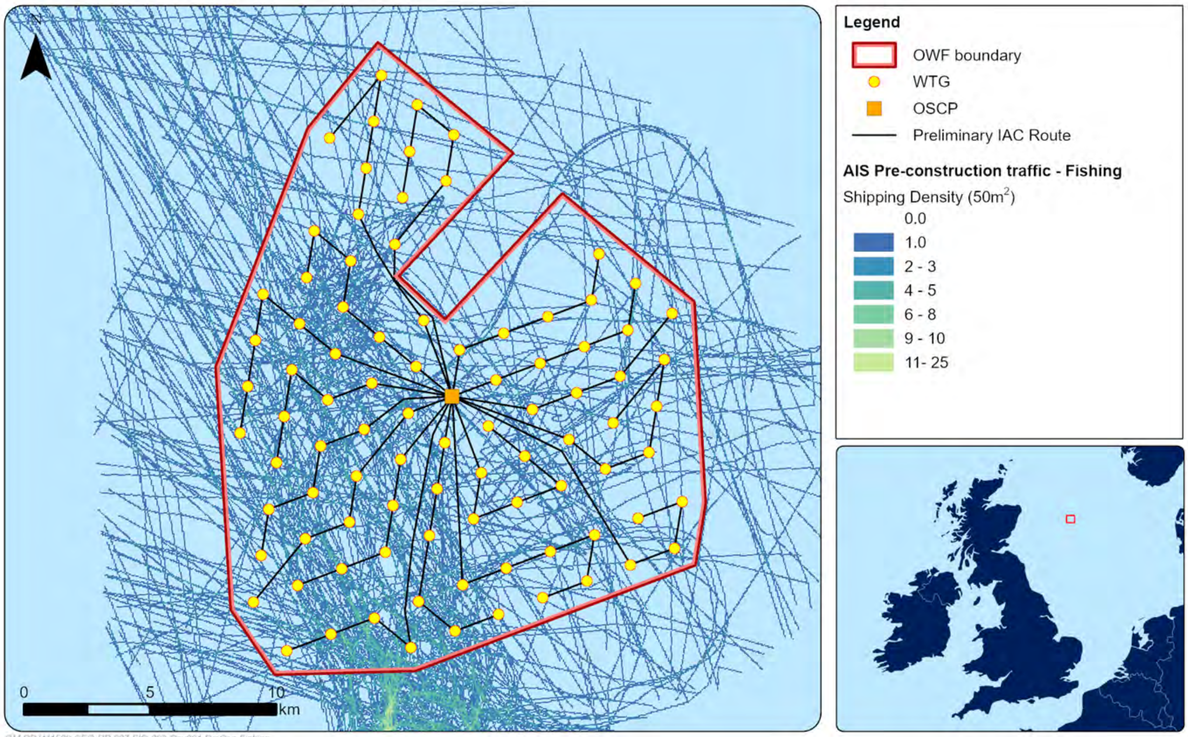


Figure 17: Pre-Construction Fishing Vessel Traffic

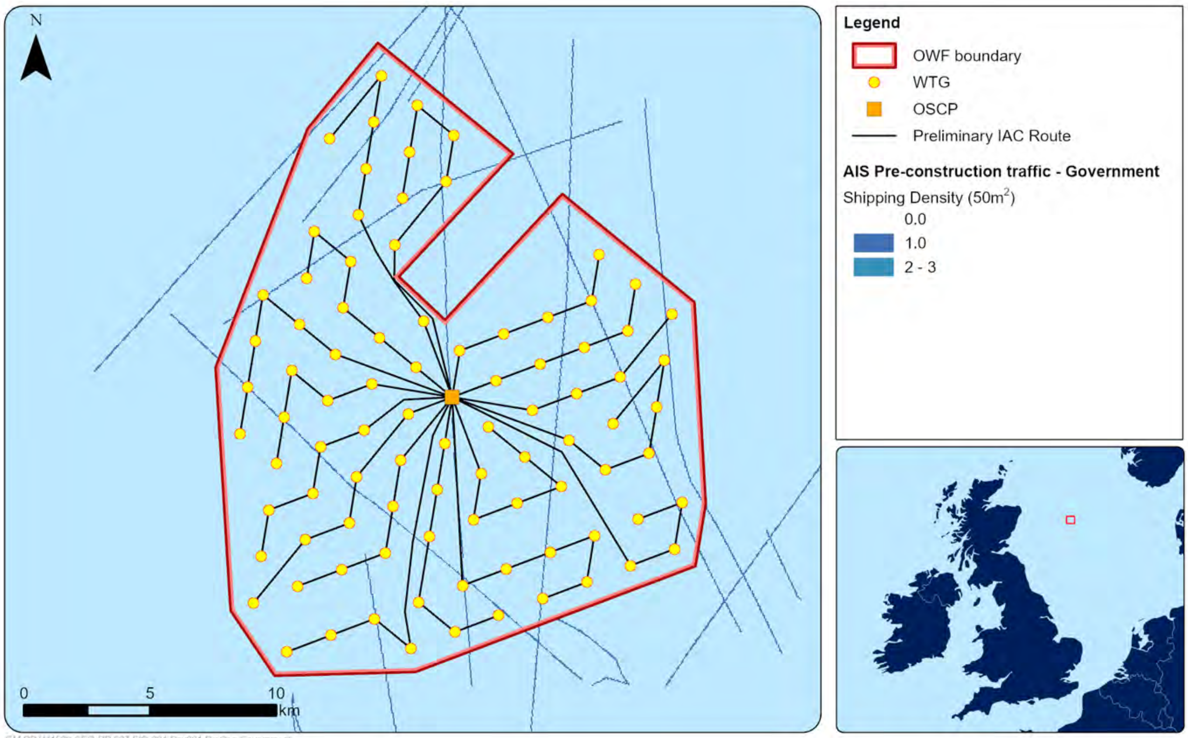


Figure 18: Pre-Construction Government Vessel Traffic

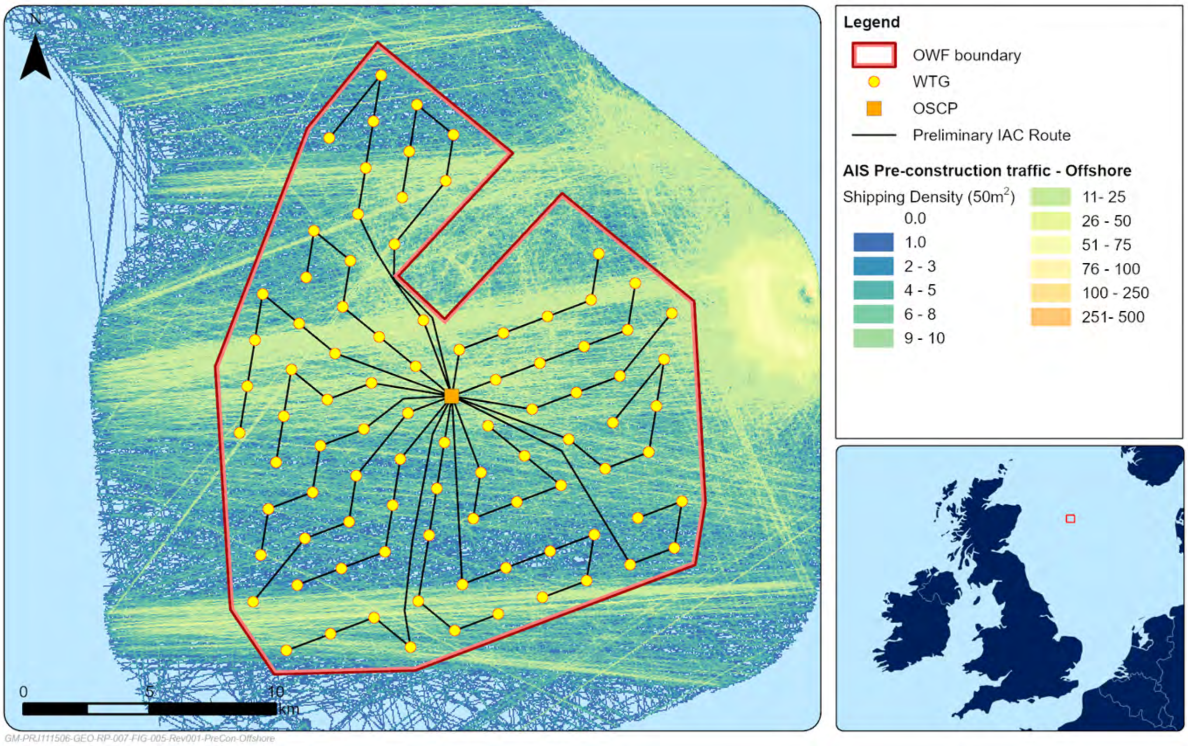


Figure 19: Pre-Construction Offshore Industry Vessel Traffic

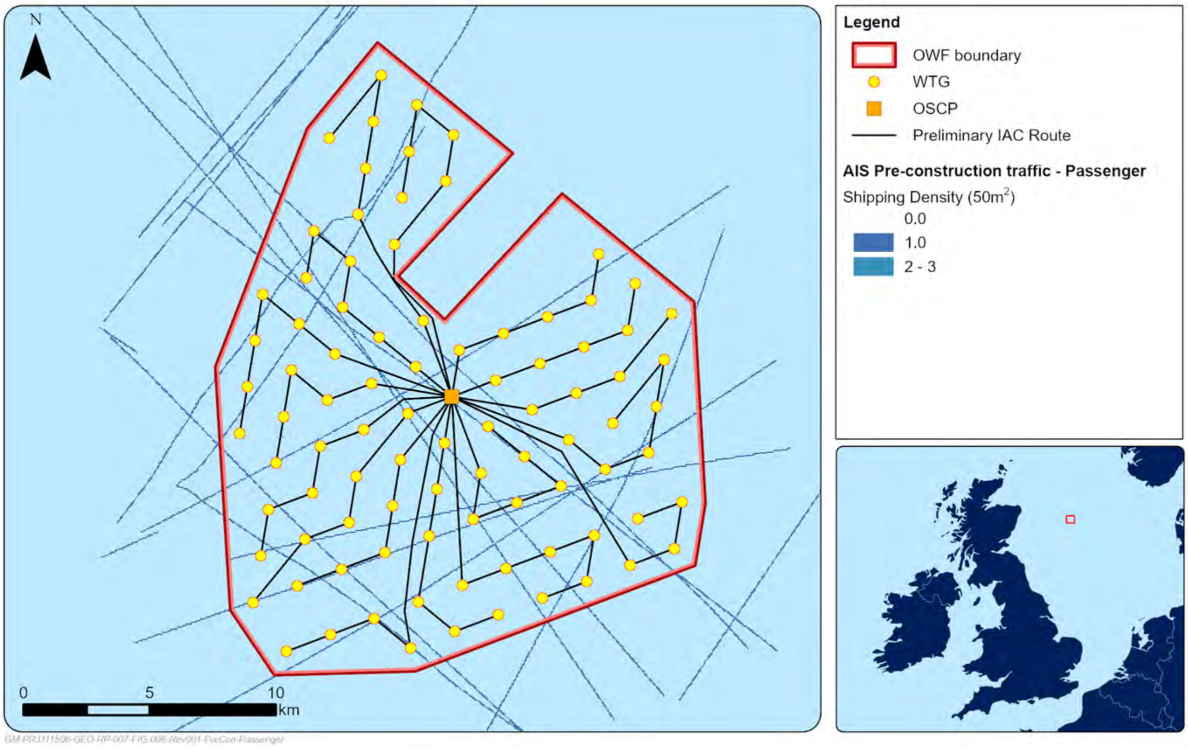


Figure 20: Pre-Construction Passenger Vessel Traffic

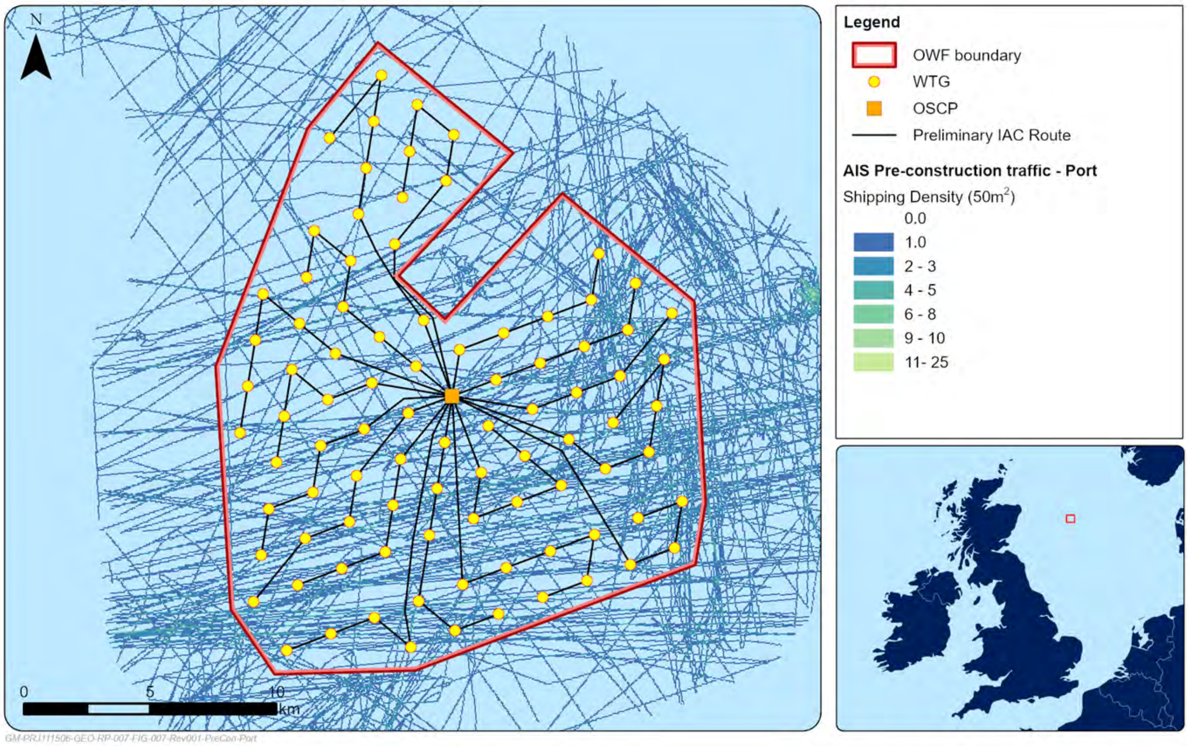


Figure 21: Pre-Construction Port Vessel Density

Categorising the vessel traffic density into vessel types shows that the vast majority of traffic can be attributed to offshore industry vessels, with the next most numerous vessel types being fishing and cargo vessels. Fishing vessel traffic density is higher along the western side of the lease area.

Global Maritime have completed an exercise of re-distributing shipping traffic around the wind farm lease area to model the vessel traffic that would be expected post-wind farm installation, where it would be expected that the vessels previously transiting the lease area would adjust course to avoid the turbines once installed. This was conducted with assistance from Senior Mariners within Global Maritime who provided input into the modelling and a review of the post installation shipping activity. The post-installation shipping activity was used to conduct the CBRA as this is more representative, with some of the vessels that are seen in the historic data crossing the lease area, now crossing the export cables, with an overall greater number of vessels crossing the export cable. A summary of the modelled traffic can be seen in Figure 22.

This shows the vessels previously crossing the windfarm and redistributes them to their most likely new transit route spatially given a criteria of exit point and entry point of the lease area, as well as the wider to and from destinations taken generally from wider open-source density mapping of the area. This also adds in any service vessels for the windfarm expected to be additionally used for operations and maintenance throughout the lifetime of the Wind farm. This process typically redistributes a greater level of traffic crossing the export cable corridor. The post-construction vessel traffic is redirected along the northern, eastern and southern edges of the site. Vessel traffic across the site itself is reduced, but the vessel traffic associated with the windfarm itself (as well as erroneous crossings of vessels of other types) means some vessel traffic across the site can still be expected.

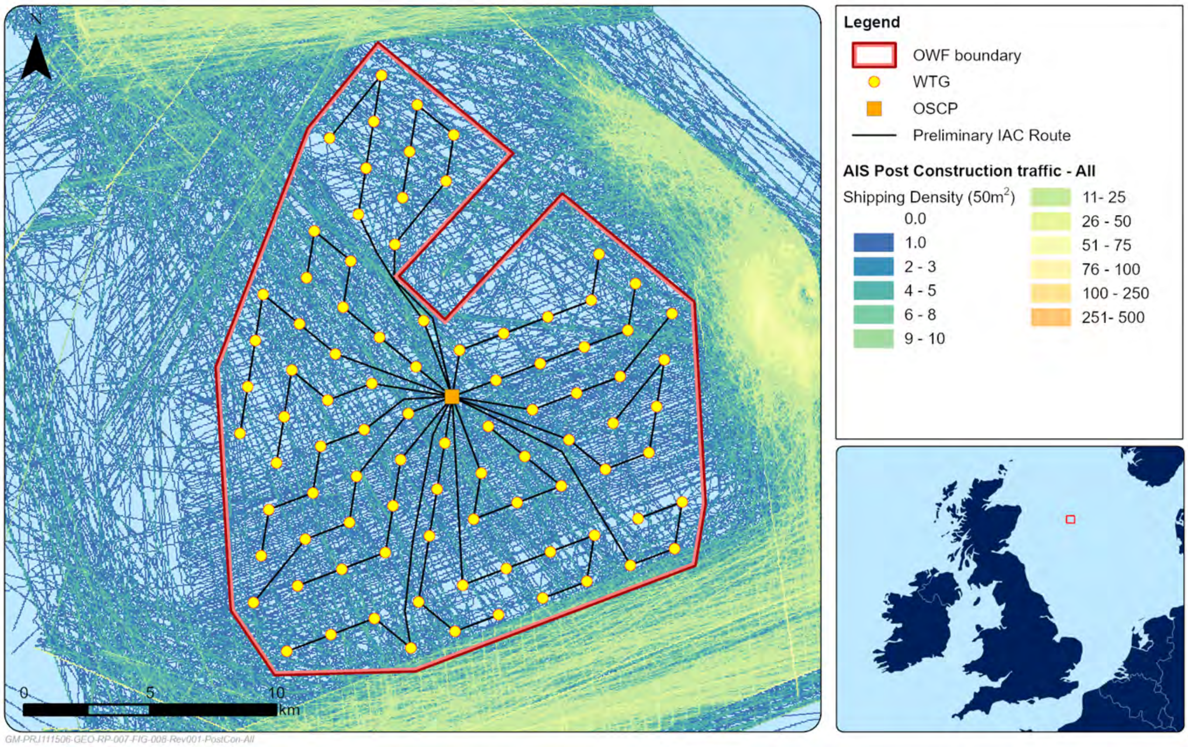


Figure 22: Post Construction Vessel Density

5.2.2.2 Fishing Activity

Commercial fishing is a hazard to subsea cables (even armoured cables) where fishing gear interacts with the seafloor, potentially resulting in damage due to impact or snagging. It should also be noted that a cable can pose a risk to the fishing vessels themselves if left on or close to the seabed, as small vessels can founder if snagged on a significant obstruction, of particular concern in areas of strong currents. For example, fishing vessels have been known to founder when trawl gear has become snagged on subsea infrastructure and attempts to free the gear have been unsuccessful.

As can be seen from the AIS data shown above, fishing vessel density is highest along the western side of the site, with the highest density occurring immediately south of the south-western corner. The SSS data from the geophysical survey (Ref. 8) detected 140 trawl scars, and 9 fishing nets and 2 fishing traps.

Given this fishing activity, it is clear that protection will need to be implemented against the risk of damage through impact / snagging of bottom trawl gear with the cables. Although the presence of the wind farm, once constructed, would deter most vessel activity, it cannot be guaranteed that fishing activity would entirely stop within the site. In the case of the identified fishing methods currently employed in the region the following threatline depth is considered reasonable below a non-mobile seabed:

- Fishing gear threatline depth in sand/mud ~0.2 m

- Fishing gear threatline depth in Soft Clay ~0.3 m
- Fishing gear threatline in bedrock/glacial till ~0.1 m

These values are in line with the Carbon Trust CBRA guidance (Ref. 14), which provides an estimate of maximum penetration of fishing bottom trawl equipment. It is noted that the risk of emergency anchor deployment described previously provides a greater threatline and is the governing case along the cable routes.

5.2.2.3 Stability/Fatigue

Surface laid cables are subject to loading from waves and currents and this could result in cable movement and migration across the seabed. Excessive movement on the seabed could cause abrasion and/or fatigue issues. Wave induced movements will be likely in shallow areas towards the shore approaches and therefore would be unlikely to affect the seabed on the Cenos site. If the cable is unstable then abrasion can occur where unburied cable is migrating across the seabed and 'rubbing against' outcropping rock, often causing significant damage.

Cable migration is also likely to increase the risk profile, as the cable movement is likely to cause a cable fault. It is also possible that the cable position will no longer be accurately identified on marine charts and this is likely to result in an increased risk from other primary hazards such as vessel anchors, fishing and construction activities. However, power cables such as the proposed are heavy and likely to have high friction with the seabed, therefore damage to the cable is more likely to occur than large displacements with suitable continued cable performance.

Whilst cable migration and fatigue may be issues for unburied cables, where a fatigue life of 20 years may be assumed in less energetic environments, experience indicates that minimal burial/embedment is usually required to ensure on-bottom stability. Therefore, where practical it is recommended that cable burial is planned unless not practical or proven to not be necessary with further in-depth analysis. If the cable is not to be buried due to outcropping rock or other factors, a more detailed cable protection strategy including the following is recommended:

- Micro-routing is undertaken to take advantage of any local features (gullies, ridges, depressions) to avoid freespans and shelter the cable where possible.
- On-bottom stability and fatigue assessments should be carried out to investigate the cable response and ascertain the likelihood for damage of the cable and the likely fatigue life under the loading regime.
- Plan appropriate mitigation methods i.e., pinning by anchoring or rock dumping, external around, additional internal stiffeners/armour, etc.

Cable burial is planned for the full length of the cables regardless of string to provide stability and a minimum level of protection to the cables.

5.2.3 Secondary Hazards

5.2.3.1 Mobile Sediments

The geophysical survey report from ROVCO (ref. 7) does not indicate the presence of significant mobile features within the wind farm site. If there is the presence of sediment mobility at the site, this could result in (deeper) burial of cables sections and/or the exposure/freespanning of previously buried sections, as the bedforms migrate. Therefore, the following should be considered:

- The performance of the cable when buried, confirming that there is not a risk of overheating at the possible burial depth due to the mobile sediments in this area.
- The increased risk of primary hazards such as fishing, anchoring and stability/fatigue due to mobility and exposure of the cable.

It is recommended that an allowance be made for sediment mobility where appropriate, with increased burial depth in areas of confirmed mobile features following further studies. The threatlines discussed in this report are based on the 2023 bathymetry, as the SSBL could not be adequately generated with the gaps in the MBES data (section 4.6). It is recommended that a geophysical survey completion campaign is conducted, and the results of this should be considered alongside this CBRA study to calculate an SSBL and the total installation depth of lowering required to adequately protect the cable for its full design life.

5.3 Probabilistic Risk of Anchor Strike

A probabilistic assessment of the cable anchor strike risk due to the identified shipping activity has been performed following the carbon trust guidelines (Ref. 14) using Global Maritime's GIS based approach. This has been performed using the site AIS data which was adjusted to model the post-windfarm construction traffic.

This method evaluates the external threat to the cable by considering the amount of time vessels spend within a critical distance of the cable and the probability that a vessel might have an incident that requires the deployment of an anchor. The effect of water depth and bathymetric profile is considered very important and is included as a qualitative factor.

The calculation for the probability of a cable strike is given by the following formula:

$$P_{strike} = P_{traffic}\,P_{wd} \sum_{1}^{No.\ ships\ in\ Section} \frac{D_{ship}}{V_{ship} * 8760hrs\ per\ year} P_{incident}$$

Where:

$P_{traffic}$: Probability modifier based on the tolerable level of risk

P_{wd} : Probability modifier for nature and depth of seabed

V_{ship} : Ship speed (metre/hr)

D_{ship} : Distance travelled by ship's deployed anchor in area under consideration (metre)

$P_{incident}$: Probability of incident occurring for that vessel size and type

$8760hrs$: Facture to annualise the results

Values for the above parameters are shown in the table below:

Parameter	Description / Comments	Value Used

$P_{traffic}$	Probability modifier to determine acceptable level of risk. Indicates the percentage of vessels for which burial is required for protection. Conservative value used for initial assessment.	1
P_{wd}	Indication of risk due to seabed profile and water depth. Values chosen as per the Carbon Trust guidelines.	See ref. 14)
V_{ship}	Individual vessel speeds taken from AIS data when crossing cable, with a maximum speed of 2 knots	Various
$\boldsymbol{D_{ship}}$	Distance travelled by the anchor when deployed to exert its holding capacity and immobilise the vessel. Vessel outside of a distance equal to D_{ship} from the cable is not a hazard. Calculated on vessel mass (m) taken as displacement, and estimated Ultimate Holding Capacity (UHC) which is estimated for each individual vessel.	$D_{ship} = \frac{m * V_{ship}^2}{4 * UHC}$
$P_{incident}$	This is the probability of an incident occurring on the vessel which requires the deployment of an anchor. This is taken as the probability of engine failure in single engine tankers in the North Sea, as per DNV guideline DNV-RP-F107	1.75×10^{-1} incidents per year per vessel

Table 13: Parameter values of probabilistic risk assessment

Vessel DWT (t)	**Minimum Water Depth (m)**			
	0-10	**10-30**	**30-50**	**>50**
0	1	0.1	0	0
2000	1	0.3	0	0
5000	1	0.5	0.1	0
20000	1	0.9	0.3	0.1

Table 14: P_{wd} values according to water depth and vessel DWT

Possible anchor penetration can be estimated, based on the soil properties and the typical anchor sizes (fluke length) used by vessels categorised by their deadweight tonnage. As described within Section 4, the seabed along the cable route consists primarily of silty sands and clay units of varying thickness overlying soft clays or higher-strength clays. The penetrative ability of anchors of different sizes in these variable soil conditions must be considered in the CBRA. This is summarised in the below table for the vessels identified. This is representative results for a single soil layer only, the full modelling performed for the results presented later in this report and shown in the alignment charting utilises a multiple layer solution from the available geophysical data.

Vessel Deadweight (DWT, Te)	Maximum Anchor Fluke Length (m)	Anchor Penetration in Unit S1 (Sands with occasional gravel and boulders) (m)	Anchor Penetration in Unit C1b (sandy Clays and clayey Sands) (m)	Anchor Penetration in Unit C6 (Stiff Coal Pit Clays) (m)
1000	0.8	0.6	2.2	0.6
2000	0.9	0.7	2.5	0.7
5000	1.2	0.8	3.1	0.8
10000	1.3	1.0	3.6	0.9
20000	1.6	1.1	4.2	1.1
50000	1.9	1.4	5.2	1.3
100000	2.2	1.6	6.0	1.6
200000	2.6	1.8	7.0	1.8

Table 15: Anchor penetration in the geological units used in the CBRA model

5.4 CBRA Results

The threat lines based on modelled post-windfarm installation shipping density and seabed composition were produced for each of the five cable route options. The threat lines were interpreted to define recommended burial depths for sections of the cables to satisfy the risk requirement and minimise burial depth where possible to reduce installation costs through maximising tooling choice and reducing installation schedules. The results for each of the strings are summarised below. The tables detail the recommended depth of lowering, the strike return period and corresponding DNV risk category (Ref. 12) for each IAC. Cumulative strike return period and corresponding DNV risk category is also shown for each string. The strike return period is equal to $1/P_{strike}$. As P_{strike} is annualised, this gives the theoretical period in years between anchor strikes on the cable based on the probabilistic CBRA calculation i.e. the number of years statistically within which one anchor strike will occur.

DNV Risk Category	P_{Strike}	Return Period (years)
1	<0.00001	100,000+
2	0.00001 - 0.0001	10,000 to 100,000
3	0.0001 - 0.001	1,000 to 10,000
4	0.001 - 1	1 to 1,000

Table 16: DNV risk categories (ref. 12)

String	Cable	Section Length (km)	Recommended Burial Depth (m)	Strike Return Period (Years)	DNV Risk Category
A	A1	3.228	0.5	>1,000,000	1
	A2	4.946	0.5	>1,000,000	1
	A3	1.863	0.5	>1,000,000	1
	A4	1.864	0.5	>1,000,000	1
	A5	1.863	0.5	>1,000,000	1
	A6	3.228	0.5	>1,000,000	1
B	B1	6.766	0.5	>1,000,000	1
	B2	3.228	0.5	>1,000,000	1
	B3	1.864	0.5	>1,000,000	1
	B4	1.863	0.5	>1,000,000	1
	B5	1.864	0.5	>1,000,000	1
	B6	1.863	0.5	>1,000,000	1
C	C1	1.864	0.5	>1,000,000	1
	C2	1.863	0.5	>1,000,000	1
	C3	1.864	0.5	>1,000,000	1
	C4	1.863	0.5	>1,000,000	1
	C5	1.864	0.5	>1,000,000	1
D	D1	1.864	0.5	>1,000,000	1
	D2	1.863	0.5	>1,000,000	1
	D3	1.864	0.5	>1,000,000	1
	D4	1.863	0.5	>1,000,000	1
	D5	1.864	0.5	>1,000,000	1

String	Cable	Section Length (km)	Recommended Burial Depth (m)	Strike Return Period (Years)	DNV Risk Category
E	E1	3.228	0.5	>1,000,000	1
	E2	1.863	0.5	>1,000,000	1
	E3	1.864	0.5	>1,000,000	1
	E4	3.228	0.5	>1,000,000	1
F	F1	4.93	0.5	>1,000,000	1
	F2	1.864	0.5	>1,000,000	1
	F3	1.864	0.5	>1,000,000	1
	F4	1.863	0.5	>1,000,000	1
	F5	1.864	0.5	>1,000,000	1
	F6	3.228	0.5	>1,000,000	1
G	G1	10.125	0.5	>1,000,000	1
	G2	1.863	0.5	>1,000,000	1
	G3	1.867	0.5	>1,000,000	1
	G4	1.863	0.5	>1,000,000	1
H	H1	3.228	0.5	>1,000,000	1
	H2	1.863	0.5	>1,000,000	1
	H3	1.864	0.5	>1,000,000	1
	H4	1.863	0.5	>1,000,000	1
	H5	1.864	0.5	>1,000,000	1
	H6	1.864	0.5	>1,000,000	1
I	I1	7.478	0.5	>1,000,000	1
	I2	1.863	0.5	>1,000,000	1
	I3	1.863	0.5	>1,000,000	1
	I4	1.863	0.5	>1,000,000	1
	I5	1.866	0.5	>1,000,000	1
	I6	1.864	0.5	>1,000,000	1
J	J1	1.864	0.5	>1,000,000	1
	J2	1.863	0.5	>1,000,000	1

String	Cable	Section Length (km)	Recommended Burial Depth (m)	Strike Return Period (Years)	DNV Risk Category
	J3	1.864	0.5	>1,000,000	1
	J4	2.643	0.5	>1,000,000	1
	J5	1.865	0.5	>1,000,000	1
	J6	1.863	0.5	>1,000,000	1
K	K1	10.262	0.5	>1,000,000	1
	K2	1.865	0.5	>1,000,000	1
	K3	1.863	0.5	>1,000,000	1
	K4	1.863	0.5	>1,000,000	1
L	L1	3.228	0.5	>1,000,000	1
	L2	1.863	0.5	>1,000,000	1
	L3	1.864	0.5	>1,000,000	1
	L4	1.863	0.5	>1,000,000	1
	L5	1.864	0.5	>1,000,000	1
M	M1	1.864	0.5	>1,000,000	1
	M2	3.227	0.5	>1,000,000	1
	M3	1.864	0.5	>1,000,000	1
	M4	1.863	0.5	>1,000,000	1
	M5	3.228	0.5	>1,000,000	1
N	N1	3.906	0.5	>1,000,000	1
	N2	1.863	0.5	>1,000,000	1
	N3	1.864	0.5	>1,000,000	1
	N4	1.863	0.5	>1,000,000	1
	N5	1.864	0.5	>1,000,000	1
O	O1	3.228	0.5	>1,000,000	1
	O2	1.863	0.5	>1,000,000	1
	O3	1.864	0.5	>1,000,000	1
	O4	1.863	0.5	>1,000,000	1
	O5	1.864	0.5	>1,000,000	1

String	Cable	Section Length (km)	Recommended Burial Depth (m)	Strike Return Period (Years)	DNV Risk Category
P	P1	4.93	0.5	>1,000,000	1
	P2	1.864	0.5	>1,000,000	1
	P3	1.864	0.5	>1,000,000	1
	P4	1.864	0.5	>1,000,000	1
	P5	1.863	0.5	>1,000,000	1
	P6	1.864	0.5	>1,000,000	1
Q	Q1	1.864	0.5	>1,000,000	1
	Q2	1.863	0.5	>1,000,000	1
	Q3	1.864	0.5	>1,000,000	1
	Q4	1.863	0.5	>1,000,000	1
	Q5	1.864	0.5	>1,000,000	1
	Q6	1.863	0.5	>1,000,000	1

Table 17: CBRA results by IAC

String	Length (km)	Cumulative Strike Return Period (Years)	DNV Risk Category
A	16.992	2,149,035	1
B	17.448	6,384,298	1
C	9.318	8,157,686	1
D	9.318	12,452,496	1
E	10.183	5,929,158	1
F	15.613	5,713,822	1
G	15.718	3,291,110	1
H	12.546	1,430,824	1
I	16.797	880,068	1
J	11.962	1,755,555	1

K	15.853	1,347,253	1
L	10.682	2,496,283	1
M	12.046	1,655,433	1
N	11.36	2,397,111	1
O	10.682	1,661,845	1
P	14.249	1,592,214	1
Q	11.181	1,050,905	1

Table 18: Cumulative Strike Return Period for each string

5.4.1 Results and Discussion Summary

The results of the CBRA have allowed the determination of suitable target depth of burial of 0.5m along all IACs. The outcome of the analysis has shown that no individual sections of the cable, when categorised by the recommended DOL, have a DNV risk category above 1 (equivalent to the probability of the cable being struck by an anchor in 100,000 years or greater). There is no standard of what risk level is acceptable, and this is down to the Cenos's appetite to risk, and the lowering of costs during the installation phase, but typically across the industry having a risk of DNV Category 2 is considered appropriate for export cables, which have a higher impact of failure than individual inter-array cables.

Whilst it is common for different cable burial depths to be assigned in different areas of a wind farm site, as the risk from vessel traffic is relatively low, and the ground conditions relatively consistent across the site, a uniform burial depth has been assigned. Although the risk may be acceptable even with surface-laid cables, burial is recommended to provide a minimum level of protection and stabilization.

The Risk Return Period for all cables has been calculated as >1,000,000 years. The CBRA model outputs this period if the calculated value is infinite, i.e. there is no quantifiable risk of anchor strike. However, a rogue anchor strike cannot be ruled out and therefore the risk cannot be stated as zero.

Cumulative risk return period for each string has also been calculated, none of which exceed DNV category 1. All cumulative risk return periods are above 1,000,000 years, except that for string I. However, this is still at 880,068 years, equivalent to DNV category 1.

6. BURIAL ASSESSMENT STUDY

6.1 Overview

As described previously, GM have assessed seabed conditions for the lease area to define recommendations for cable installation methodology. Burial techniques considered, at this stage, to be most appropriate for the site, can be taken forwards for further consideration when additional information becomes available.

At a high level, the site can be described as consisting primarily of clayey and silty sands overlying stiff clays and glacial till, with some occasional areas of outcropping stiff clays and glacial till. Boulders and cobbles are common at the surface throughout the length of the route.

6.2 Cable Lay Options

The main construction options available for the offshore sections of the cable burial are:

- Post-lay burial of the cable utilising separate cable lay and burial campaigns with cable buried by cable plough or trencher after it has been laid on the seabed.
- Simultaneous lay and burial with a cable plough or trencher deployed and operated from the cable lay vessel.
- Pre-lay trenching utilising separate trenching and cable lay campaigns where the trench is pre-cut by a large plough or trencher followed by cable lay directly into an open trench followed by backfill by plough, natural backfill or rock placement.

The most appropriate method will depend on a number of factors, for example the cable type being approved for the method to be utilised or the required vessel/trenching tool combination being available for the desired installation dates and the burial conditions on the cable route. These three methods are discussed briefly below.

6.2.1 Post-Lay Burial

In a post-lay burial operation, the cable is laid onto the seabed by a cable installation vessel. The same vessel can then return to carry out cable burial with the cable in place. Alternatively, a different vessel could carry out burial at a later date.

With the post-lay burial method, there is a risk of damage to the unburied cable during the intermediate stage between cable lay and burial operations from primary threats or cable instability at seabed due to metocean conditions. Post-lay burial with tools such as jet trenchers and mechanical cutters can induce tensions into the pre-laid cable due to cable friction as the cable travels through the machine. This can lead to free spans in sand wave areas. In addition, a kink can develop in the cable ahead of the machine.

Operational risks are always present surrounding launch and recovery of the burial machine from the vessel, especially in high sea states. Landing the machine on the seabed safely over the cable can also be a challenging operation in energetic seas and will be performed according to weather limitations identified through installation analysis. Cable routing through the machine can also be problematic, most modern tools are equipped with manipulators to manually pick up and load the cable into the trencher for burial, however, there are some machines in service that require diver assistance.

6.2.2 Simultaneous Lay and Burial

During simultaneous lay and burial, cables are laid and buried simultaneously with burial equipment (plough or burial sled) being towed by the cable laying vessel or barge or operated from the cable laying vessel where a self-propelled Remotely Operated Vehicle (ROV) is utilised generally for jetting or mechanical cutting burial methods. These may be free flying ROVs, or self-propelled tracked machines (TROVs).

This approach offers immediate protection to the cable and cable tension can be managed by the cable lay system as the cable enters the plough or trencher. The cable catenary can be monitored by ROV during the process.

6.2.3 Pre-Lay Trenching

For this method, a separate vessel would tow a plough or operate a trencher to cut a trench in the seabed for which the cable can be laid into by the cable lay vessel in a separate operation.

Laying the cable into a pre-cut trench is sometimes considered to offer a low-risk construction method, whereby a plough/trencher is used to create a large trench, carrying out the aggressive soil cutting without the presence of the cable. The cable can then be laid into this trench and back filled by a second pass with a backfill plough. This approach would mean that the risk of damage to the cable is much reduced compared to the post lay burial and the simultaneous lay and burial techniques. However, difficulties exist in co-ordination of the two vessels working together in this way, for accurate positioning of the cable and for maintaining an open trench, due to sediment infill. Broad disturbance of the seabed in this manner may also be less desirable from an environmental consenting perspective.

6.3 Cable Burial Options

The results of the CBRA detailed in section 5.4 ultimately determine what type of burial tool to use to achieve the recommended DOL. In general, burial methods can be categorised as ploughing, jetting or mechanical cutting. Different burial tools are optimised to perform in certain sediments – the types of tools available on the market are discussed in sections 6.3.1, 6.3.2 and 6.3.3 below, and section 6.3.4 evaluates their suitability for the site based on conditions discussed in section 4 and the results of the CBRA, detailed in section 5.4.

6.3.1 Cable Ploughs

Cable ploughing is the process of towing a subsea plough with a vessel with sufficient bollard pull capability to create a trench for the cable. This method has the largest effective range of soil conditions and will be suitable up to the dense / very dense sand and stiff clays. Ploughs are generally utilised for simultaneous lay and burial whereby the installation vessel tows the plough, and the cable is routed through the plough and laid into the open cut trench with assistance from a depressor on the plough. The trench can then either be left to backfill naturally or a backfill plough can be used to relocate the spoil from the initial trenching into the open trench on top of the laid cable.

Alternatively, ploughs can be used prior to cable lay to cut a trench along the lay route for which the cable can then be laid into. This may be required where boulder presence is a concern and the pre-lay trenching is used to clear smaller boulders, with some tooling setups quoting the capability to clear boulders up to 1m diameter. Where this is deemed necessary, specialist boulder clearance ploughs can be utilised. When pre-cutting a trench, this should only be undertaken if it can be performed close enough to cable lay operations or in a non-mobile seabed such that the trench will not naturally backfill prior to cable lay.

Some additional considerations should be made when considering ploughing operations. Firstly, manoeuvrability is restricted for ploughing compared with alternative burial methods. This limits the achievable cable turn radius and means that less complex lay routes can be achieved. Many ploughs also require longer burial transition lengths compared with alternate methods. Geological hazards should also be considered such as excessive seabed slope resulting in risk of tooling overturning or less control of cable burial depth, along with soft soils resulting in risk of plough sinkage. Tool selection should also be made considering features of available tooling on the market, for example some will require diver assistance for routing of the cable through the tooling and some will have diverless options which may be favourable in terms of project risk and commercial costs of diving operations.

As discussed, cable ploughs can work in a wide range of soils and are suitable for low to high strength clays which can be sheared but less suitable for dense sands which can increase tow force and likelihood of plough ride out. The high tow forces exhibited in sand are caused as the plough shears the granular material, this causes dilatancy in front of the shear. As the sand accumulates strain, the soil particles dilate, increasing void space. Pore pressures become negative causing apparent strength gain, until pore pressures eventually equalise due to water ingress. To reduce the high tow force generally exhibited in sands during ploughing, the cable plough shear can be fitted with a jet system. This addition of water reduces the negative pore pressure and therefore reduces the tow forces experienced.

The different types of cable burial ploughs are listed below:

- Conventional Narrow Share Cable Ploughs
- Advanced Cable Ploughs – a new generation of cable ploughs, which have been designed to achieve increased depth of lowering for subsea cables of depths up to 3.0 m.
- Rock Ripping Ploughs – suitable for outcropping rock, or where the seabed strata are exceptionally hard and beyond the capabilities of a conventional narrow share plough.
- Vibrating Share Ploughs - consists of a narrow share, which is vibrated to ensure cutting progress through difficult seabed conditions, such as gravel beds.

6.3.2 Jet Trenchers

A jetting system works by fluidising and/or cutting the seabed using a combination of high flow low pressure and low flow high pressure water jets to cut into sands, gravels and soft to firm clays. Jetting tooling is generally effective from very loose up to medium dense or dense sands. In some cases, a dredging/eduction system is employed to suck out the fluidised material to leave an open trench into which the cable then falls by its own weight.

The mechanisms for jet trenching in clays and cohesionless sands/gravel soils are fundamentally different. Sands are most efficiently fluidised by a large volume of water (high flow / low pressure water jets) flowing over the trench cross sectional area, with a large water volume required to lift the sand particles into suspension. Coarser materials such as gravels fall rapidly through the water column and as a result it is very difficult to displace these soils and adequately bury a cable through coarse soils. Reduced DOL could be seen in areas of higher gravel content.

Conversely, in clays, the jet pressure (low flow / high pressure water jets) must be greater than a threshold value at which the clay can be cut, related to the undrained shear strength. As this pressure is partly generated through the available hydrostatic pressure at seabed, it may not be suitable in low water depths unless modified. A second pass may also be required utilising the high flow / low pressure setup, to remove the pre-cut clay blocks if the flow rate on the first pass is not sufficient.

The trench will naturally backfill due to settlement of sand particles out of suspension. Based on experience with jetting machines, between 60% and 80% backfill in the trench will be achieved to natural seabed level if one pass is required.

Jetting systems are most commonly used for post lay burial operations; however they can be used for simultaneous lay and burial. Tooling for this method are generally Tracked Remotely Operated Vehicles (TROVs) but may also be free flying tools or towed tools mounted on skids. Jetting nozzles are generally installed on two long jetting swords that are lowered into the seabed either side of the cable to fluidise / remove seabed material to allow the cable to be lowered. Sword lengths can be adjusted according to the required burial depth of the cable.

Jet trenchers generally reduce the risk of cable damage as there is no planned direct contact with the cable, and therefore can also be used near cable crossings. Multiple passes are possible in order to achieve target depth of lowering/depth of cover requirements. However, where deep burial is required, cable detection may be difficult.

Jetting tools are generally best suited to softer and looser ground conditions. Where bearing capacity of soil is a concern to support the TROV weight, buoyancy can be installed as required to reduce the submerged tooling weight, however lighter tools or free-flying tools are more susceptible to metocean conditions and may have high weather limitations. Tooling operations may be limited by water depth for submerged pumps to work, in which case surface water supply may be required when working in shallow water for example near landfall areas.

6.3.3 Mechanical Cutters

Mechanical trenchers are usually post lay burial machines suitable for consolidated high strength cohesive sediments and weak/fractured rock. They typically fall into two categories mechanical rock wheel cutters or mechanical chain Excavators. These two types are discussed below:

- Mechanical rock wheel cutters: Mechanical rock wheel cutters are used to cut narrow trenches into hard or rocky seabed and consist of a rotating wheel disc, which is fitted with rock cutting teeth.
- Mechanical chain Excavators: The chain Excavator tool consists of many cutting teeth and a further number of mechanical scoops which are used to transport the

cut material away from the trench. An auger is sometimes in place, which helps move material away from the trench or clogging the chain cutters.

When trenching in hard clays and rock for both rock wheel cutter and mechanical chain trenchers a narrow slot is formed into which the cable is lowered. The material is removed as the action of the cutting causes it to be broken down into its constituent parts.

Significant thicknesses of sand and gravel are likely to hinder performance as the tool relies on the action of ripping cohesive soils. To aid with lowering, mechanical cutters can be fitted with a rear jet leg/eduction system which clears the trench of granular soils and back fill material. A mechanical cutter is generally fitted with a depressor which guides the cable through fluidised materials increasing DOL. On rocky outcrops, the seabed might be too uneven for the trencher to operate normally. Typically, sudden changes in elevation should be smaller than 0.3 m and slopes below 15°, although this is dependent on the size and limitations of the specific trencher. Aratellus' Leviathian Trencher, for example, has fully articulated separate tracks and so is likely to be much more capable of operating on an irregular, rocky seabed.

The magnitude of the seabed relief, in the context of the footprint of a mechanical trenching tool, must be understood in detail in order to assess the stability of the trencher and its ability to progress across the seafloor.

It is common that mechanical cutters are utilised for short sections of cable routes where required to trench within hard ground. These are generally avoided where possible due to slow progress rates, for this reason they are generally used for pre-lay or post-lay trenching rather than simultaneous lay and burial which would significantly slow the progress of the cable installation vessel.

Mechanical cutting tools are deployed and controlled from a vessel with sufficient capacity crane or A-frame LARS. They are generally TROV type vehicles and can include additional features such as cable loading manipulators. Cutting tool wear is a particular consideration for these tools, and rock wheel / cutting chain teeth should be selected carefully based on the seabed material.

Mechanical cutting can cause substantial suspension of sediments in the vicinity of the tool, which can be a risk for environmental consenting. The relevant authorities should be consulted on what mitigation is required, but this could include for example turbidity monitoring buoys.

6.3.4 Cable Burial Tool Suitability

As described above, multiple different types of burial tools are available for subsea cable installation, however the performance of the tools will vary depending upon the sediment type and other factors. The general suitability of different burial equipment is given within Table 19, taken from the BERR report 2008 (Ref. 18).

Cable Burial Devices	Burial Device Options	Sediment Type					
		Sands	Silts	Gravel	Weak Clays	Stiff Clays	Rock
Cable Burial Ploughs	Conventional narrow share cable ploughs	✓	✓	✓	✓	✓	✗
	Advanced cable ploughs	✓	✓	✓	✓	✓	✗
	Modular cable ploughs	✓	✓	✓	✓	✓	✗
	Rock ripping ploughs	✓	✓	✓	✓	✓	✓
	Vibrating share ploughs	✓	✓	✓	✓	✓	✓
Tracked Cable Burial Devices	Jetting systems	✓	✓	?	✓	✗	✗
	Rock wheel cutters	P	P	P	✓	✓	✓
	Chain excavators	P	P	✓	✓	✓	✗
	Dredging systems	✓	?	?	✗	✗	✗
Free Swimming ROVs with Cable Burial Capability	Jetting systems	✓	✓	?	✓	✗	✗
	Dredging systems	✓	?	?	✗	✗	✗
Burial Sleds	Jetting systems	✓	✓	?	✓	✗	✗
	Rock wheel cutters	P	P	P	✓	✓	✓
	Chain excavators	P	P	✓	✓	✓	✗
	Dredging systems	✓	?	?	✗	✗	✗

KEY

✓	=	Should be capable of burial.
?	=	Performance will be related to the type of sediment and the power delivery to the burial device.
P	=	Performance possible in the sediment type but not an ideal application.
✗	=	Unlikely to be capable of burial.

Table 19: Burial performance comparison

Figure 23 below from DNV (Ref. 10) also summarises burial method suitability in various ground conditions and thus the optimum ground conditions for each burial tool can be derived. As can be seen for cutting, by adding a dredging (or jetting) system, the graph could be extended into looser materials. The figure also highlights that ploughing is more suitable for a wider range of soils. Therefore, in sites with variable material, ploughing could be the optimum tool. However, this is based purely on soil conditions, other factors such as water depth, seabed features and commercial factors all influence the choice of burial asset used.

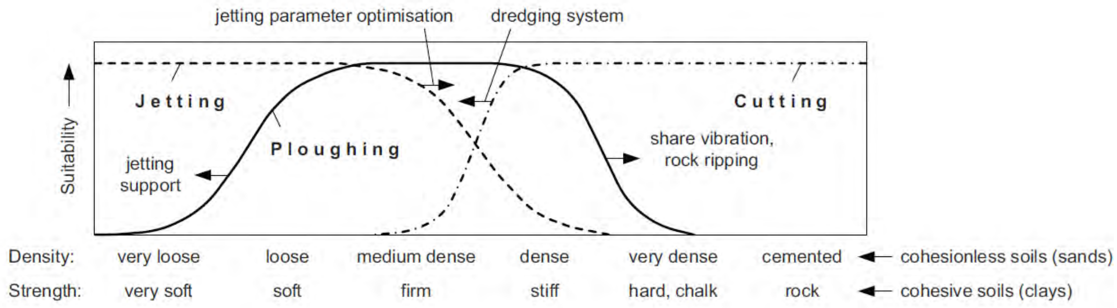


Figure 23: Indicative burial tool suitability in different ground conditions

In general, it can be summarised that the ploughing method is suitable for a wide range of ground conditions, jetting techniques are suitable for soft or loose soil conditions, and mechanical cutting is required in the hard or dense soils and rock.

The above is a guide that should be considered when selecting burial methodology, however, additional considerations need to be made with regards to the site conditions when selecting the burial tooling and methodology. For example, boulder presence within the lay route, geological features, potential mobility and expected metocean conditions will all factor into the decision-making process when selecting burial tooling, along with the overall methodology including if post-lay burial or simultaneous lay and burial will be most suitable. This is further described for each method in the sections below.

The three methods described above have differing anticipated progress rates within different seabed materials. These anticipated progress rates are shown in the table below:

Burial Tool	**High Level Anticipated Progress Rate**	
	Loose Sand / Soft Clay	**Dense Sand / Stiff to Hard Clay and Rock**
Jet Trencher	200-350 m/hr	100-200 m/hr
Cable Plough	200-400 m/hr	200-400 m/hr
Mechanical Cutting	200-350 m/hr	70-150 m/hr

Table 20: Anticipated burial tool progress rates

6.4 Burial Assessment Methodology

A preliminary burial assessment and tool suitability assessment has been undertaken for the cable route options for most commonly used tools, as described above. This assessment was based on the anticipated ground conditions along each cable as well as tool specifications and limitations that might affect suitability. Each tool to be used alone is graded into the following system:

- Suitable – Likely to achieve burial
- Possible – Unlikely to achieve consistent burial throughout

- Not Suitable – Unlikely to achieve burial

The tool suitability has been assessed for the seabed conditions and required burial depths for each of the Inter array cables. Broadly speaking, sections of the cable routes can be categorised by burial class which is determined by the seabed composition within the target depth of lowering established within the CBRA (Section 5), but does not account for other geohazards such as boulders, which are assumed to have been mitigated against prior to the burial campaign. These burial classes are shown below:

Burial Class	Description		Achievable Burial Depth
	General	Geology	
A	Full burial expected to target depth in a single trencher pass. Constant burial conditions with low variability. Optimal plough or jetting progress rate.	Thick very loose to medium dense sands / silts and soft to firm clays. Generally flat seabed and absence of features hindering burial operations.	Target or beyond
B	Reduced and variable burial conditions. Reduced progress rate possible. Potential for reduced success with jetting tools and / or multiple passes expected with potentially different tooling such as mechanical cutters.	Medium dense to dense sand and stiff to very stiff clay or loose / soft sediment sitting over a dense to very dense unit. Minor bedforms, slopes <10 degrees expected to impact tool progress.	Within Target
C	Poor burial expected, with possible areas of cable exposure. Slow progress rate with high risk of not achieving full burial.	Stiff to very stiff clay and up to very dense sand/silt and consolidated sediment / bedrock, or a thin unit of loose/soft sediment sitting over a dense to very dense unit or rock. Bedform slopes > 10 degrees.	Potentially Less than Target

Table 21: Cable burial classification

6.5 Burial Assessment Results

The results of this analysis, in the form of Burial Assessment tables, are shown in full in Appendix C. The most suitable tools and burial classes for defined sections of the cable routes are summarised in Figure 24.

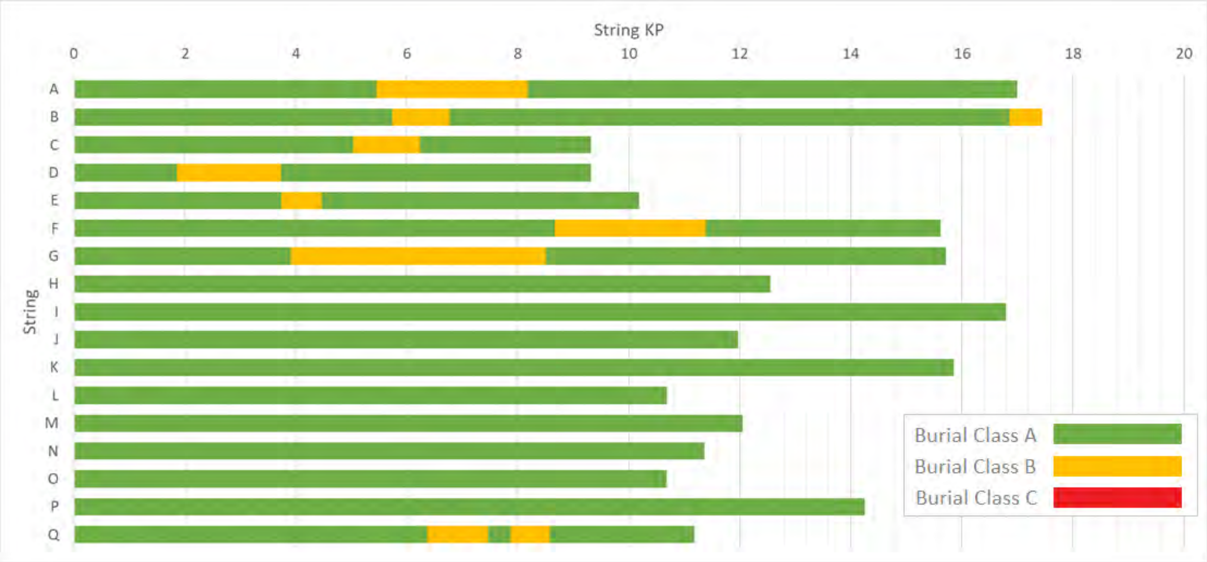


Figure 24: Burial Assessment Summary

Using the results of the CBRA and planning a burial strategy with regards to tool type and burial depths in the BAS allows the recommendation of an installation methodology of the options outlined in section 6.2, and suggested vessels and tools to conduct the operation. The recommended DOL is set at 0.5m across all of the cable routes, using a jetting tool achieve this.

Of the 221.95km of cable distance, 204.17km (92%) is designated as burial class A, 17.78km (8%) designated class B and 0km designated class C. The primary geohazards across the entire site are the potential gravels in the surficial sands reducing sediment suspension during jetting, and the presence of boulders resulting in a collision risk to burial tools and free-spanning risk to the cable. As these geohazards are site-wide, they are not detailed in each row of the BAS table to avoid repetition of the information. The BAS table highlights sections of the cables with the presence of subcropping stiff clays associated with the Coal Pit formation, which may require multiple passes or remedial protection to achieve the recommended DOL.

The certainty of the Burial Classes is highly dependent on the certainty of the geological conditions. With only geophysical data available, this certainty is reduced. However, considering the uniformity of the seabed and consistent DOL recommendation, areas of burial class A associated with sands throughout the burial profile can be assigned a high certainty. Areas designated class B (generally due to the presence of gravels and subcropping clays) are less certain, as the gravel content and stiffness of the clays have a significant effect on jettability, and these properties can only be determined through geotechnical sampling.

6.6 Recommended Cable Installation Methodology

The suggested methodology for installation of the inter-array cables is post-lay burial using a jetting sled or ROV. The vast majority of the shallow sediments along the IAC routes are suitable for burial via jetting, with the only areas of potentially more challenging burial conditions occurring where there are isolated patches of gravels, pebbles and cobbles, which may reduce burial by reducing suspension and eduction of the sediments in the trench. Other onerous sections are where the routes cross areas of stiffer clays within the recommended DOL. These stiffer clays associated with the Coal Pit formation may require additional jetting passes with a powerful jetting tool.

Use of a cable plough in simultaneous lay and burial or a subsea plough in pre-lay trenching would also be a potentially suitable burial method. Ploughs will work well in any areas of gravel, pebbles and cobbles, and their performance can be improved in sands via jetting assistance. However, as the vast majority of the wind farm site is covered by sands and soft clays, and the majority of the total IAC distance requires only 0.5m of burial, a cable plough may not be the most suitable option for installation. Additionally, due to the cable being present in simultaneous lay and burial, there is an increased risk of damage during installation.

If a pre-lay trenching solution is used, the cable is removed from the high-energy trenching operation altogether, however more passes are required with separate TSVs to conduct initial trenching, cable lay and backfill (if required). After trenching, the surficial sands naturally backfill the trenches before cable lay, reducing burial depths. This can however be mitigated by digging a deeper trench initially, conducting remedial eduction passes before cable lay or jetting passes after cable lay to ensure the required DOL is reached.

With both ploughing methods, a jetting ROV would likely need to be mobilised alongside the plough to provide burial in any sections of the cable route where the plough had to be recovered and graded in or out, for example on approach and departure from a cable/pipeline crossing or approach to the OSS.

Mechanical trenching is not recommended for installation. Although technically feasible in the given conditions, the resulting progress rates and tool wear would likely make the campaign prohibitively expensive and inefficient. The chosen method for installation will ultimately depend on the tools and vessels available on the market at the time of construction.

Several sections of the IAC routes feature identified boulders and boulder fields, which if routed through, could damage a potential burial tool during installation. It is therefore recommended that extensive micro-routing of the cables is conducted to determine if a boulder clearance campaign is required prior to any cable lay and burial campaigns, using either a towed clearance plough or a grab system. Some clearance ploughs in the industry are reconfigurable for pre-lay trenching and post-lay backfill or can do both clearance and trenching simultaneously.

6.6.1 Suggested Jetting Tools

Seaway 7 - Louis Dryfus Travocean ROVJET 1210

The ROVJET 1210 is a free-swimming or tracked jetting ROV with up to 900kW of power, capable of trenching to 3m below seabed. It utilises separate front and rear high pressure and low pressure jets to account for differences in sediment composition, which should allow for jetting to 0.5m depth in the expected soil conditions. It is a relatively compact vehicle at 6.2m in length and is permanently mobilised on Seaway 7’s Aimery cable vessel.

Figure 25: Louis Dryfus Travocean ROVJET1210

Helix Energy – T1400 Hybrid Trencher

The T1400 is a more powerful jetting option for array cable burial, able to operate in soils up to 100kPa, and can also be mobilised with a mechanical cutter able to operate in soils up to 250kPa. Helix operates two of these trenchers, which have a demonstrated history successfully working on IAC projects. The trenchers are deployed with a dedicated LARS system allowing deployment in up to Lloyds sea state 6.

Figure 26: Helix Energy's T1400 Hybrid trenching tool

6.6.2 Suggested Ploughing Tools

DeepOcean ACP2 Plough (or equivalent) – Simultaneous Installation and Burial

Many companies now own and operate jet-assisted cable ploughs as they are cost-effective ways of installing cables based on the smaller well-established telecom cable ploughs. The main disadvantage of using ploughs is having to run the cable through them to achieve burial, which can increase the risk of cable damage. A jet-assisted plough should however perform well in all but the hardest soil conditions encountered on the route. Ploughs can also be started from the beach and towed offshore, allowing potentially uninterrupted burial from landing to deep water, though they can only be operated by a cable lay vessel with a sufficient bollard pull and A-frame.

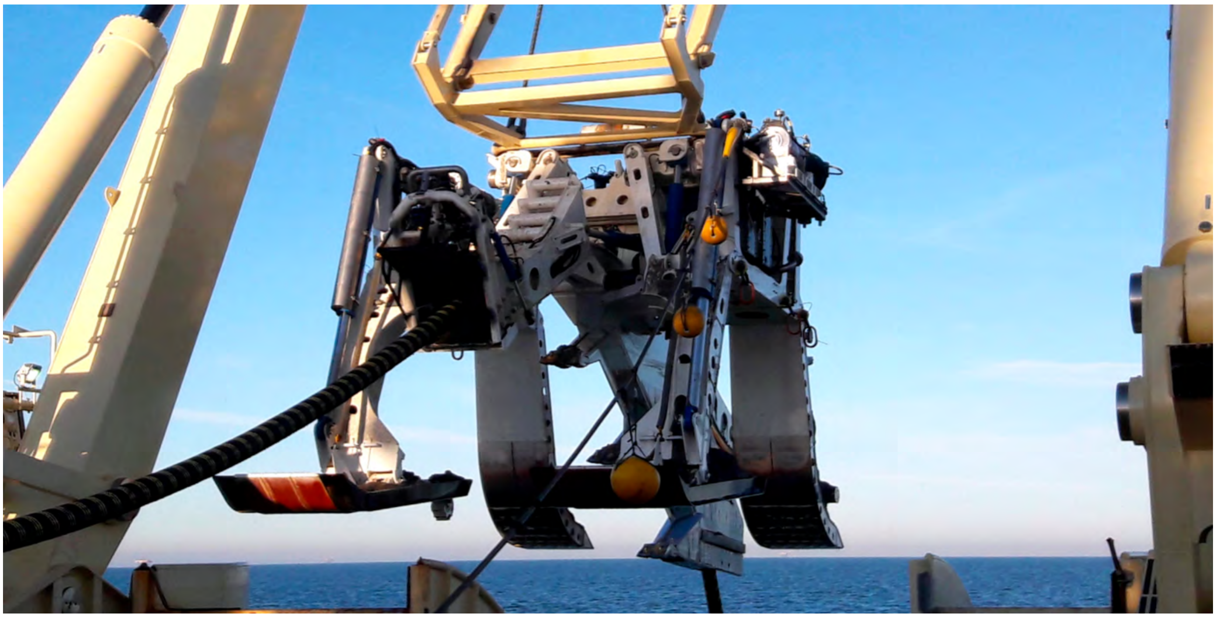


Figure 27:Delta Subsea's ACP2 cable plough

Asso Subsea Hydroplough – Simultaneous Installation and Burial

The Hydroplough is a versatile burial tool designed to handle wider diameter products such as three-core power cables, umbilicals and certain flexible pipelines. The design differs from many other cable ploughs, using a swivelling stinger on a sled base. The stinger features high-pressure water jets to fluidise the seabed, improving progress rates and burial depths in soils up to 120kPa in shear strength. The plough can be mobilised with different length stingers to suit the required burial depths and expected soil conditions. The plough should perform well in all but the hardest soil conditions encountered on the route.

Figure 28: Asso Subsea's Hydroplough during deployment

6.6.3 Suggested Installation Vessels

Seaway 7 – Seaway Aimery

The Aimery is a 95m purpose-built cable-laying vessel with a track record of installation in wind farms IAC and oil and gas projects. The vessel has two cable carousels with a combined capacity of 4,250Te, and a sheltered quadrant handling system, making it ideal for conducting second-end and pull-in operations. The vessel is also mobilised with the ROVJET 1210, meaning it can conduct cable burial via jetting where feasible, and has a 20Te A-frame for launch and recovery of other trenching vehicles and quadrants.

Figure 29: Seaway 7's Seaway Aimery Cable Ship

Van Oord Nexus

The Nexus is a modern DP2 class 122m long cable ship with a 5000Te capacity carousel, equipped specifically for installation of export and inter-array cables. It has no A-frame so may not be suitable for plough operation, but it does have a 100Te main crane and bespoke cable protection and quadrant handling system to aid in installation of second-ends, making it a potentially efficient cable installation platform for an inter-array post-lay burial campaign.

Figure 30: Van Oord's Nexus Cableship installing cable at a wind turbine monopile

Boskalis Ndurance

The Ndurance is a purpose-built cable laying vessel with a low draught and the ability to beach itself. The vessel has DP2 classification and a six-point anchor mooring system for station keeping in challenging conditions. It has a large turntable of 5000Te capacity and a 70Te capacity A-Frame for deployment of burial tools, which Boskalis also provide as turn-key solutions.

Figure 31: Boskalis' Ndurance Cable Laying Vessel

6.6.4 Suggested Boulder Clearance Tools

6.6.4.1 Ploughs

Helix Energy i-Plough

As an alternate method to simultaneous lay and burial, the i-plough provides simultaneous boulder clearance and trenching to 1.9m depth and can be reconfigured and re-deployed after cable lay to backfill the trench. The plough is a large and heavy tool, requiring a dedicated high bollard pull vessel, but is capable of trenching in firm clays and diamicton and can remove sub-surface boulders and deposit them to the sides of the trench. Though the plough may not be as effective in areas of sands, it could still be used to clear boulders and sand waves for a jetting tool to then bury the cable. If the surficial sands are stable enough and cable lay happens shortly after the plough runs, a jetting tool would not be required at all. The plough was originally built to work on the Kriegers Flak and Vesterhav North and South windfarms and has since also been used on the Kincardine floating OWF.

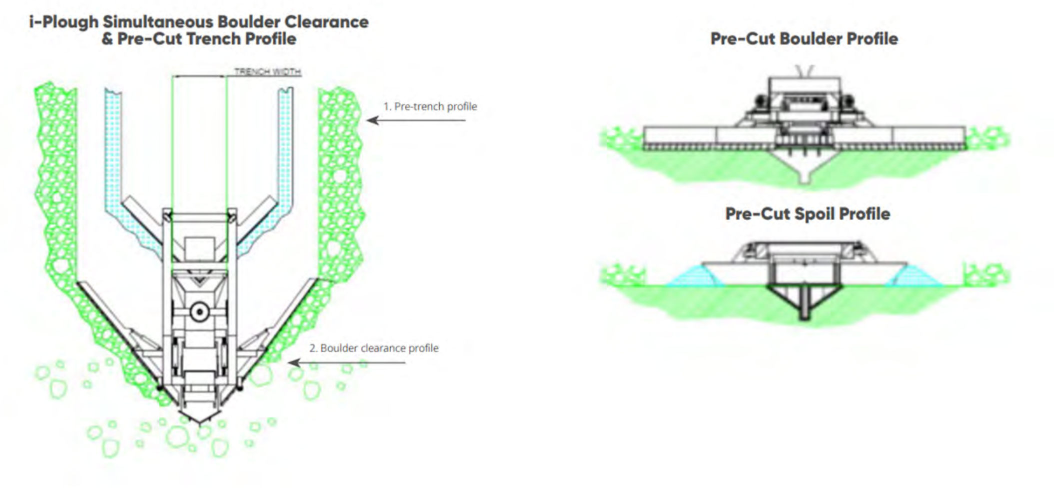


Figure 32: Diagram of the i-Plough's trenching profiles

Asso Subsea's Multi-Functional Plough

The multi-functional plough is similar in design and ability to Helix Energy's i-plough, designed to be reconfigurable to conduct boulder clearance, pre-lay trenching and backfill in separate passes. The plough can clear boulders up to 2m in diameter and create a Y-shaped trench up to 1.7m in depth. Like the i-plough, it has been used previously in similar conditions on the Kriegers Flak wind farm site.

Figure 33: Asso Subsea's Multi-Functional Plough

6.6.4.2 Tine Grabs

Tine grabs (also often called orange peel grabs) are a relatively simple method for boulder relocation outside of the cable corridor, and typically consist of a hydraulically actuated grab, deployed by a vessel crane and accurately positioned using a module with acoustic sensors and thrusters.

Figure 34: UTROV's TA01 tine grab

6.7 Remedial Protection

Remedial protection is used after cable installation to effectively increase the DOB over any sections of the cable where the recommended DOL was not achieved by burial alone, by placing additional material to provide further coverage and protection to the cable. Various methods of remedial protection are available, but primarily these fall into three categories:

- Rock Dumping or Subsea Rock Installation (SRI)
- Concrete Mattresses
- Cable Protection System (CPS)

Often, combinations of these methods are used to protect cables.

Rock Dumping or Subsea Rock Installation

Subsea Rock Installation (SRI) is the process of accurately piling rock on a location or along a route, using a specialised vessel and subsea tool. The vessels have large bulk stores for carrying the rock material, which is deposited via a fallpipe with a controllable opening at the seabed-end. The opening is controlled by the subsea tool, which usually features cameras and sonar to monitor the rock placement and thrusters for accurate positioning. SRI is typically used to provide scour protection to subsea structures and additional protection to buried or surface-laid products by means of 'artificially' increasing the burial depth.

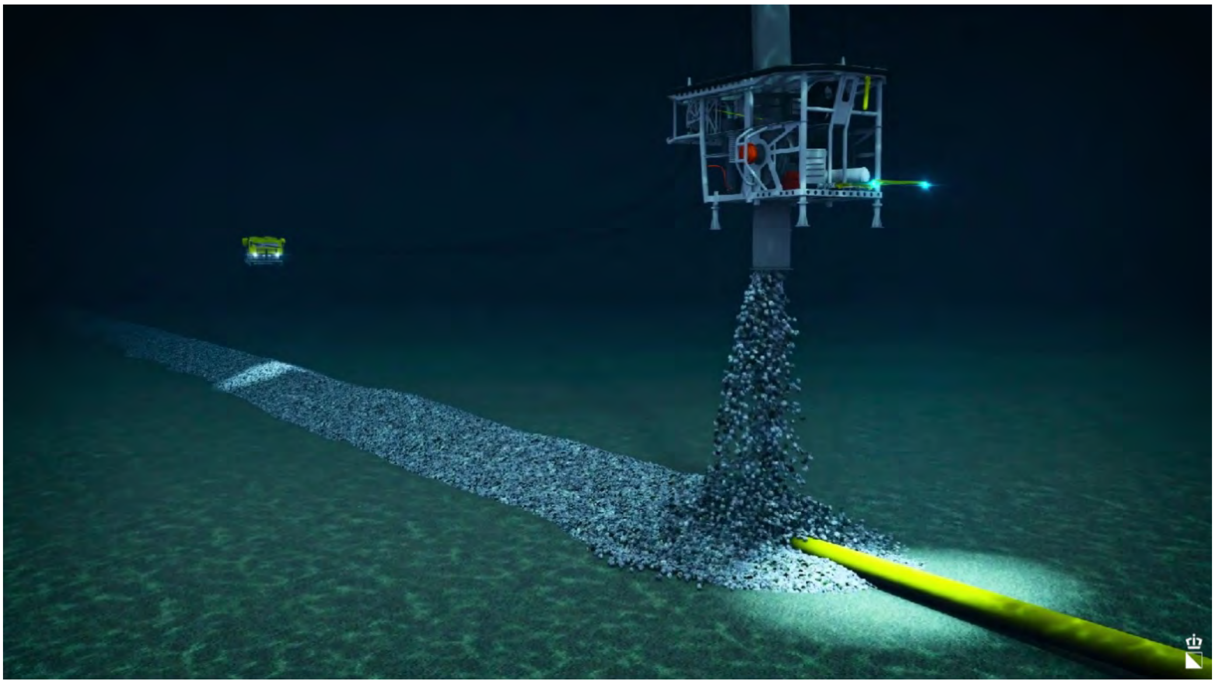


Figure 35: Boskalis' Fall Pipe ROV with integrated inspection ROV conducting rock placement

Concrete Mattresses

Concrete mattresses are standardised units constructed of interlinked high strength concrete blocks connected by a series of U.V. stabilised polypropylene rope. They are supplied in standard 6x3x0.3m units of standard density, however modifications to size, density, and shape (tapered edges for high current environments, or denser concrete) can be engineered bespoke to the locality. They are used industry wide for a variety of subsea projects for applications such as cable and pipe crossings as well as providing dropped object protection and stability.

Crossing construction generally involves installation of pre-lay mattresses that would be placed on top of the existing cable, normally 2-3 mattresses are installed next to each other along the length of the existing cable. This provides a crossing corridor for the cable to be laid over. The central mattress is normally marked with highly visible paint to aid cable lay. Following cable lay, post-lay mattresses can then be placed on top of the new cable. Additional mattresses are generally required to provide cover for the entire cable transition length either side of the crossing, such that risk of exposure is removed. Mattresses are installed using a vessel's crane to lift and deploy a mattress suspended on a Mattress Lay Frame (MLF) or Mattress Installation Frame (MIF).

Figure 36: Mattress Installation Frame

Cable Protection Systems (CPS)

Cable Protection Systems can be used to describe various types of ducting or 'shell' that can be applied to a cable during its installation, acting as an additional layer of armour around the cable. Different systems have different applications that they are most suited for but could all be feasible for use as additional protection in areas where the recommended DOL is not reached.

Cast iron split pipe is common in the industry providing impact protection and on bottom stability in areas of high currents or shore landings. This is installed on the cable during lay, and in this solution could be laid direct to the seabed and not buried, buried with a jet trencher (subject to soils) or laid into an open cut trench, followed by infill to level of the seabed provided by rock or Mass Flow Excavation.

Figure 37: Cast Iron Split Pipe on a Cable

As an alternative, 'Uraduct' - a name trademarked by Trelleborg, but commonly used to describe a polyurethane split pipe solution can be used. It has the same attributes in terms of object and abrasion protection as the cast iron split pipe but without the on bottom stability control (unless weighted, which is feasible).

Figure 38: Cable Protection System - 'Uraduct' Polyurethane

The use of Subsea Rock Installation to create rock berms is assumed the base case for remedial protection along the cable routes.

6.7.1 Remedial Protection Locations

Locations for remedial protection are selected based on the results of the BAS, where the recommended DOL is not likely or will not be achieved. This is generally in areas with more onerous burial conditions, or areas where the cable cannot be buried such as when crossing existing assets such as other cables and pipelines. The final areas to employ remedial protection will be determined by the results of the as-protected survey, where cable tracking is used in conjunction with bathymetry to determine if the cable has reached the recommended DOL.

Whilst 0.5m of burial is recommended across all cables, the results of the CBRA indicate that shallower burial may be acceptable from a risk perspective, assuming that DNV risk category 1 is deemed acceptable by the client. Therefore, in sections where 0.5m burial is not achieved, remedial protection may not be required to achieve an acceptable risk profile. As part of the rock volume calculations in this report, only pipeline crossings are considered to require SRI.

6.7.2 Pipeline Crossing Rock Berm Design

The 22" Culzean pipeline crosses the south of the lease area in a southwest to northeast direction, and as described in section 2.6, it is crossed by four IACs – G1, I1, J4 and K1.

Due to the large diameter of this asset, pre-lay SRI would be required to create a smooth transition over the pipeline for the cable to be laid onto. Further post-lay SRI would then be undertaken to provide the required DOC. The pre-lay rock berm is designed to extend 50m either side of the pipeline, to provide a shallow gradient and smooth transition over the pipeline for the cable to be laid onto. The shape of the berm is designed to be the base of the overall rock berm (including the post-lay SRI). The height of the cable above seabed at the crossing point is much higher due to the large diameter of the pipelines.

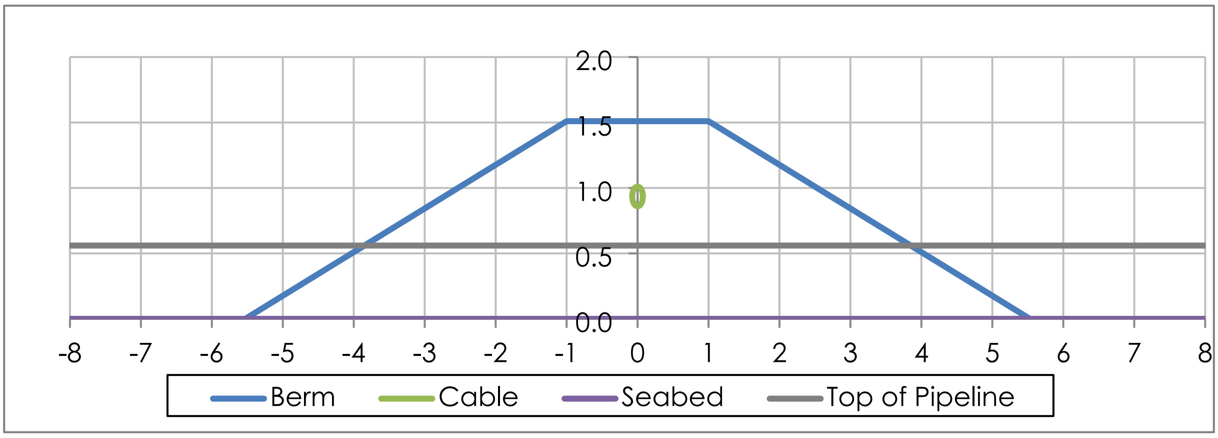


Figure 39: Pipeline crossing rock berm cross-sectional design

The berm crest height is 1.51m, as the sum of the pipeline diameter (22”), 0.3m minimum separation between the pipeline and cable, the cable diameter of 150mm and DOL of 0.5m. As with the cable crossings, the berm extends 250m either side of the crossing point, resulting in a 520m long berm including the 10m burial grade/in out sections at each end. This distance also could be reduced through consultation with the asset owner but may vary between cables and pipelines.

Up to 50m before the crossing point and 50m after the crossing point, the cable is surface laid on the seabed as the pre-lay berm starts/ends. In these sections, the berm size can be reduced to a smaller crest height, with a cross-sectional area of 3.66m^2 maintaining 0.5m coverage. This smaller berm is shown in Figure 40, and the more complex design of the pipeline crossing berm is illustrated in Figure 41 and Figure 42. With this design, the volume of rock required for each pipeline crossing is 1,834.93m^3.

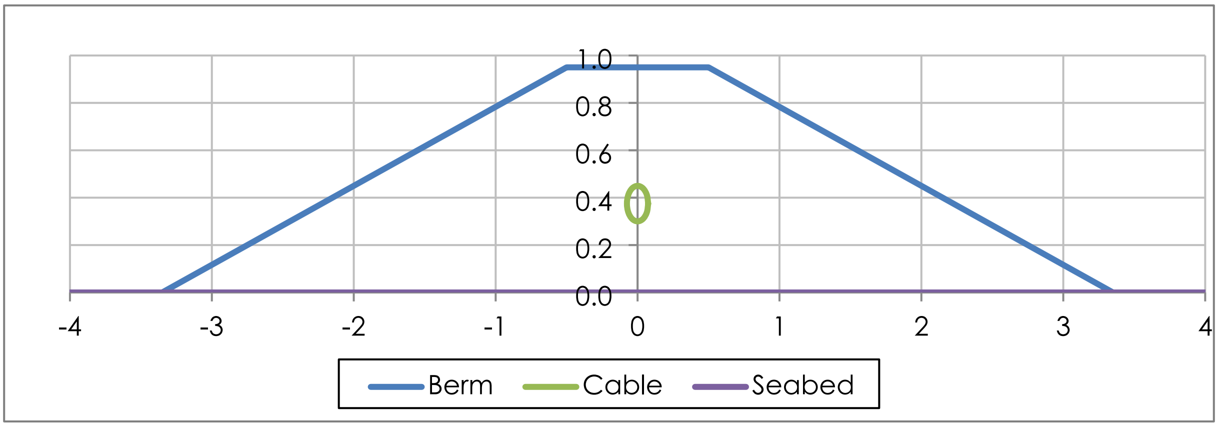


Figure 40: Surface-laid cable berm design

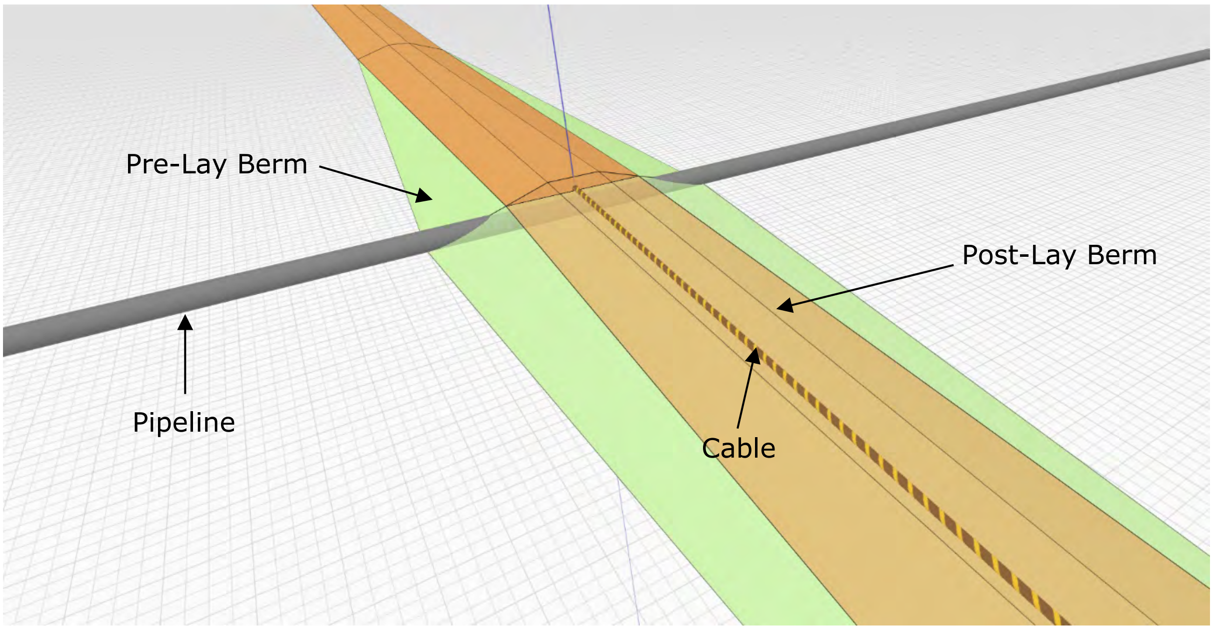


Figure 41: Pipeline crossing berm design with pre-lay berm (green) and post-lay berm (orange)

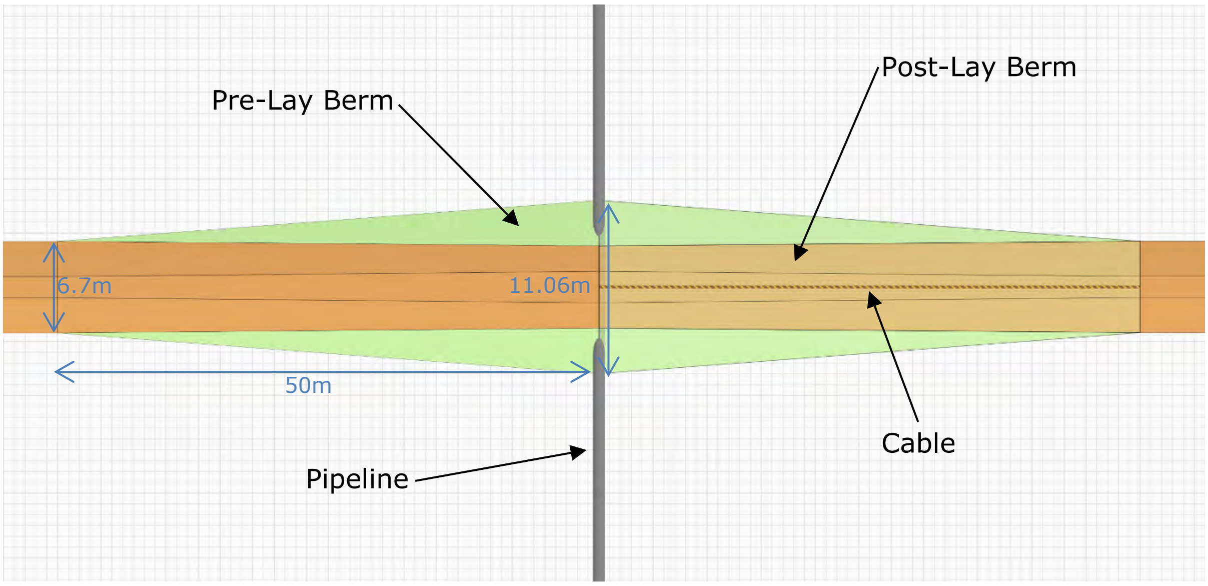


Figure 42: Plan view of pipeline crossing berm design with pre-lay berm (green) and post-lay berm (orange)

An alternative to a full-height rock berm installation would be the use of rock bags (also often called rock filter bags). Rock bags can be installed easily with a vessel crane and can also be removed more easily than a rock berm in the even of cable failure. However, installation of enough rock bags to provide sufficient height over the pipeline and coverage over the cable may take a long time. The preferred option will ultimately be determined by the agreement made between the respective asset owners. For the rock volume calculation in this report, a rock berm installed using SRI is assumed the base case.

6.7.3 Remedial Protection Summary

Locations that may or will require remedial protection have been identified, and Subsea Rock Installation chosen as the base case method for providing this protection. No sections of the cables have been identified for SRI due to the potential for shallow cable burial, as the CBRA-calculated risk remains low even with surface-laid cable. It is recommended that once burial of all cables is completed, the CBRA is run using the achieved DOL measured via cable tracking and MBES, and the strike return period calculated based on these burial depths. Should any sections be deemed higher risk, remedial protection should then be considered.

Table 22 lists the locations designated for SRI, and the corresponding rock volumes required. A total rock volume for the site is also provided.

Rock Installation Location	Volume of Rock Required (m^3)
G1	1,834.93
I1	1,834.93
J4	1,834.93
K1	1,834.93
Total:	**7,339.72**

Table 22: Estimated rock volume for IAC protection

7. CONCLUSIONS AND RECOMMENDATIONS

Global Maritime have conducted CBRA for the Cenos inter-array cable routes, including a review of the bathymetry and sub-seabed geology, and a resulting BAS, concluding on a recommended Depth of Lowering across all routes and suggested installation methodology.

An indicative IAC layout was developed based on the provided turbine layout, with routing principles applied to reduce the total cable length, avoid cable crossings and reduce pipeline crossings. These routes then formed the basis for the results of the CBRA and BAS.

The site conditions were assessed to determine the geological layers of the seabed within the OWF site area. Using the provided geophysical survey data, geological units could be spatially defined along the routes, and simplified into a two-layer ground model for input into the CBRA calculations.

The site condition assessment and two-layer ground model were then utilised using Global Maritime's CBRA method with modelled post-windfarm installation vessel traffic to analyse the anchor strike risks to the cable and propose target burial depths along each RPL to minimise the risk to acceptable levels whilst also maintaining practical burial depths along each cable route. The burial depths and risk profile for each cable is detailed within the alignment charts appended.

The predominant geological conditions are extensive soft Holocene silty sands and clays, overlying isolated regions of Pleistocene stiff clays. The thickness of the upper softer sediment layer varies across the site - in much of the site the sediment layer is deeper than the recommended DOL. The geological conditions strongly influenced the chosen recommended installation methodology.

Key risks on the site can be defined as:

- Cables with challenging burial conditions due to subcropping harder sediments:
  - A2
  - B2, B6
  - C3, C4
  - D2
  - E2
  - F4, F5
  - G1
  - Q4, Q5
- Soft surficial sediments causing trench collapse or backfill during protection campaigns
- The presence of boulders and boulder fields will prevent operation of burial tools, meaning a clearance campaign may be required to ensure safe tool operation.

It should be noted that whilst there is no specific acceptable risk value that must be attained through protection from anchor strike through burial, it is common for cables to be protected to specifications to DNV Cat 2, which is specified as a return period >10,000 years. As this is not specified by cable length, target burial depths were determined based on maintaining >10,000 years return period cumulative across each section of the cable routes as defined by changes in ground conditions.

The results of the BAS have determined a recommended installation methodology. A cable laying vessel is required, with many available in the market having specialised equipment for performing first and second-end pull-ins at wind turbines and the OSP. A post-lay jetting campaign is recommended for cable protection, utilising a powerful jetting tool that can be deployed either from the cable laying vessel or a dedicated TSV. Remedial protection is recommended at crossing points with the Culzean pipeline, consisting of the construction of a pre-lay berm and post-lay additional coverage via Subsea Rock Installation, to provide a smooth transition for the cables over the pipeline and adequate protection from external aggression. Sections of the cables where more onerous burial conditions are expected may require remedial protection to reach the CBRA-derived recommended DOL, however with the relatively low risk along the cable routes, this may not be necessary depending on what risk Cenos deems to be acceptable.

As mentioned, a key driving factor when determining the required burial depth for anchor strike protection is the soil properties, as these dictate anchor penetration. It is recommended that the CBRA is re-evaluated once a full geotechnical survey and a geophysical completion survey have been conducted. The CBRA should also be re-evaluated in the event of the cable routes being updated, with the CBRA completed for the full lease area, so the updated results can be extracted simply. With this additional information, it is also recommended that a detailed BAS with the specific burial tool(s) to be used for cable installation and consideration of the strengths of the geological units in relation to the specific tool’s ability is conducted to further optimise the cable protection methodology, further reducing burial and vessel time.

APPENDICES

APPENDIX A DESIGN RISK REGISTER

GEOHAZARD & GEOTECHNICAL RISK Register (GRR) - Cables

Project Number:	**PRJ111506**		**Project Name:**			**Cenos Floating Offshore Wind Farm Export Cables**			
GRR Review Date:	**18/09/2024**		**Project Manager:**			**Matt Owen**			
			Risk Evaluation				**Risk Evaluation**		
Ref.		**Hazard Details**	**Inherent Risk Severity**	**Inherent Risk Probability**	**Inherent Risk Level**	**Control Measures**	**Residual Risk Severity**	**Residual Risk Probability**	**Residual Risk Level**
Cable Installation	**PRJ111361**								
1	Hard Soils Within Burial Profile	Presence of hard soils can cause issues to cable installation. Trenchability along those areas is highly dependable on the geotechnical parameters of the soils and cables might be not sufficiently protected if targeted burial depths are not achieved. Exposed cables have increased risks to internal and external threats.	3	D	M	Geotechnical survey of the full cable route, and detailed assessment of the geotechnical parameters of the tertiary soil units is recommended, in order to understand the burial feasibility. The recommended burial strategy already limits exposure, in so far as possible, with use of a mechanical trencher capable of excavating the stiffer clays and Glacial Till. Remidial Protection in the form of SRI might be required in areas where more onerous burial conditions are anticipated.	2	D	M
2	Boulders at and within Seabed	Boulders of indurated and cemented material derived from the underlying geological units. Boulders create obstructions for trenching and installation activities. Buried boulders can cause reduced burial.	4	E	H	Detailed, high resolution bathymetric and side scan sonar survey. Sympathetic routing design, resilient trenching methods, boulder clearance campaigns ahead of or simultaneous with trenching.	2	D	M
3	Soft Soils at and within Seabed	Presence of soft, unconsolidated soils can cause issues to cable installation. Soft soils can cause trencher sinkage and less efficient trenching if not planned for.	3	D	M	Detailed installation engineering examining trencher types, bearing pressures and means of reducing bearing pressure if necessary.	1	B	L
4	Irregular Seabed	Presence of irregular seabed can cause issues with trencher traction and progress, also reduced burial where trencher tools pull out of seabed.	3	C	M	Detailed installation engineering examining trencher types, utilise suitable trencher. Computation of an SSBL and identification of areas that may have a possible requirement for avoidance via micro-routing or deeper burial depth to achieve recommended DoL.	2	D	M
5	Gravel Reduces Depth of Lowering	Gravels present within seabed soils may not be fully removed from trench, limiting the depth to which lowering can occur.	3	D	M	Evaluate detailed geotechnical and geophysical survey. Account for risk with increased trench depth and trenching methods to maximise suspension and eduction.	3	B	M

GEOHAZARD & GEOTECHNICAL RISK Register (GRR) - Cables

Project Number:	PRJ111506	Project Name:	Cenos Floating Offshore Wind Farm Export Cables
GRR Review Date:	18/09/2024	Project Manager:	Matt Owen

Ref.		Hazard Details	Risk Evaluation: Inherent Risk Severity	Inherent Risk Probability	Inherent Risk Level	Control Measures	Risk Evaluation: Residual Risk Severity	Residual Risk Probability	Residual Risk Level
6	Existing Asset Crossings	Four pipeline crossings create areas where the cable will be initially exposed after lay, while remedial protection is put in place. Cable is more suceptible to damage due to movement or external aggression during this time.	4	C	M	Negotiate crossing agreements with existing asset owners well in advance of cable installation. Design asset crossings based on CBRA recommended DOL to provide suitable protection to the both the existing asset and new cable. Minimise time between cable installation and remedial protection, utilise guard vessels if necessary.	3	B	M
Cable Operation									
1	Shipping	Ships can cause direct damage to exposed or insufficiently buried cables by deploying anchors either deliberately (in case of anchorages) or accidentally over / next to a cable. Direct cable strike or more likely snagging of cable can cause damage to cable (and potentially the vessel).	2	E	H	Probabilistic assessment of shipping and estimation of likely anchor penetration depth relative to seabed geology and shipping activity. Conservative approach to be taken with regard to unknown factors (e.g. number of smaller vessels without AIS). Determination of appropriate cable burial depths to provide adequate protection.	1	C	L
2	Fishing	Fishing activities can result in direct damage to exposed or insufficiently buried cables by fishing gear snagging on the cable. Also (greater) risk to the fishing vessel in the event of a snagging incident. Fishing vessels account for a proportion of the traffic in the area.	2	C	M	Assessment of likely fishing gear penetration based on identified fishing types relative to seabed geology and recommendation of burial to sufficient depth to afford adequate protection. Ongoing monitoring of fishing activity and methods as part of IMR regime. Identification of new cables on nautical charts / fishermen awareness initiatives.	1	B	L

GEOHAZARD & GEOTECHNICAL RISK Register (GRR) - Cables

Project Number:	**PRJ111506**		**Project Name:**			**Cenos Floating Offshore Wind Farm Export Cables**			
GRR Review Date:	**18/09/2024**		**Project Manager:**			**Matt Owen**			
			Risk Evaluation				**Risk Evaluation**		
Ref.		**Hazard Details**	**Inherent Risk Severity**	**Inherent Risk Probability**	**Inherent Risk Level**	**Control Measures**	**Residual Risk Severity**	**Residual Risk Probability**	**Residual Risk Level**
3	Fishing - future variations in equipment	Fishing methods and equipment could vary with time resulting in increased risk to the cables.	2	E	H	Ongoing monitoring of fishing activity and methods as part of IMR regime. The risk to the cables should be reassessed if there is a significant change in fishing activities which results in greater penetration of fishing equipment into the seabed. If necessary, mitigation actions to be taken (deeper burial, rock dump, fishing exclusion zones, etc.). Given the increased vessel running costs of deeper penetrating fishing gear (higher towing force), increase in this factor is considered unlikely, however it is possible that the locations of fishing grounds will change in future.	1	B	L
4	On-bottom Stability	Water depth and metocean conditions influence cable on bottom stability (abrasion / fatigue effects on surface laid cables, which could be exacerbated by the uneven seabed surface in areas of outcropping rock or sand waves).	2	B	L	Cables are planned to be buried for the entirety of the route. Where burial may not be possible, and alternative method of cable protection is to be considered. Water depth across the vast majority of the site is beyond typical metocean influence at surface.	2	A	L
5	Dredging / Dumping	Dredging activity can result in direct damage to cables as well as exposure of buried cables or reduction in burial, increasing risk to primary hazards such as shipping or fishing. Over-burial by dumping, can result in exceeding cable thermal / physical design parameters.	2	B	L	Consultation with dredging licence holders, as required. Identification of new cables on nautical charts / implementation of exclusion zones for dredging / dumping activity.	2	A	L

GEOHAZARD & GEOTECHNICAL RISK Register (GRR) - Cables

Project Number:	PRJ111506		Project Name:	Cenos Floating Offshore Wind Farm Export Cables				
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			Risk Evaluation				Risk Evaluation		
Ref.		Hazard Details	Inherent Risk Severity	Inherent Risk Probability	Inherent Risk Level	Control Measures	Residual Risk Severity	Residual Risk Probability	Residual Risk Level
6	Mobile Sediment / Seabed Mobility	Areas of mobile seabed may overtime expose the cable and potentially cause freespans if cable not buried to a sufficient depth. Cable exposure increases risk of impact damage. Freespans can cause fatigue damage over time.	4	B	M	Bathymetry has been utilised to generate SSBL, and to providse an assessment of seabed mobility across the site. Survey prior to the cable lay to confirm assessment of site / RPL(s). Regular survey of cables as part of IMR regime - with emphasis on any areas anticipated to be mobile. Reassessment of cable risks and mitigation works as required if cable becomes over-buried or exposed.	2	A	L
7	Soils with Insulative properties	Clays/till can have insulating properties and increase the risk of overheating, which is exacerbated by deeper burial	4	C	M	Thermal resistivity tests of the Clay-rich till should be consulted. Burial depth is however relatively shallow for the whole route. Should burial depths need reducing, CBRA calculation should be run for route section to determine if the resultant pstrike and return period are acceptable	2	A	L

APPENDIX B DRAWINGS

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APPENDIX C BAS TABLES

Cable	WTG From	WTG To	KP Start (String)	KP End (String)	Section Length (km)	Water Depth (mLAT)		Missing Bathymetry		Seabed Composition At Target Depth of Lowering	GM Ground Model				CBRA Results				Burial Recommendations							Comments
						Min	Max	Combined length (m)	%-age missing		Layer 1	Min Base of Layer 1 (mBSB)	Max Base of Layer 1 (mBSB)	Layer 2	Recommended Depth of Lowering (m)	Pstrike at Recommended DOL	Strike Return Period (Years)	DNV Risk Category	Jetting	Ploughing	Mechanical Cutting	Burial Class	Remedial Protection (m)	Assumed Rock volume for remedial protection (m^3)	Key Risks in Zone	
A1	OSP	72	0.000	3.228	3.228	-93.78	-96.47	225.54	6.98	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.130	3.000	C1b	0.5	8.63E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				Occasional gravels and cobbles in surficial Holocene sediments may reduce suspension when jetting. Boulders at the surface may obstruct burial tools. Both Geohazards are present across the entire Cenos site.
A2	61	N/A	3.228	5.450	2.222	-95.97	-96.57	259.24	11.67		S1	0.280	3.000	C1b		4.34E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
A2	N/A	72	5.450	8.174	2.724	-96.13	-96.84	276.15	10.12	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	C1b	0.290	3.000	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile from KP7.4 to KP7.9 may reduce burial depth or require multiple passes when jetting.	
A3	72	80	8.174	10.037	1.863	-96.03	-96.70	481.60	25.83	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.220	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
A4	80	88	10.037	11.901	1.864	-96.63	-97.40	1063.45	57.04		S1	0.280	3.000	C1b		5.44E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
A5	88	95	11.901	13.764	1.863	-97.02	-97.45	908.43	48.73		S1	0.230	0.340	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
A6	95	81	13.764	16.992	3.228	-93.78	-96.75	833.36	12.31		S1	0.190	1.920	C1b		2.72E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A			Very short section of Coal Pit stiff clays within burial profile from KP16.66 to KP16.75	
B1	OSP	N/A	0.000	5.738	5.738	-93.78	-96.75	726.12	70.40	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.130	3.000	C1b	0.5	1.66E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B1	N/A	71	5.738	6.766	1.028	-96.14	-96.59	166.02	2.89	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	C1b	0.260	1.130	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A			Very short section of Coal Pit stiff clays within burial profile from KP6.2 to KP6.4	
B2	71	N/A	6.766	8.312	1.546	-96.15	-96.77	113.38	7.31		C1b	0.230	1.540	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile from KP7.74 to KP8.25 may reduce burial depth or require multiple passes when jetting.	
B2	N/A	86	8.312	9.994	1.682	-96.15	-96.84	670.49	39.95	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.210	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B3	86	93	9.994	11.858	1.864	-94.01	-96.38	363.79	19.51		S1	0.180	3.000	C1b		5.44E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B4	93	94	11.858	13.721	1.863	-92.45	-94.78	919.62	49.32		S1	0.180	3.000	C1b		1.84E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B5	94	87	13.721	15.585	1.864	-92.45	-97.34	1089.30	58.43		S1	3.000	3.000	S1		1.84E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B6	87	N/A	15.585	16.850	1.265	-96.16	-96.59	400.99	31.88		S1	0.260	3.000	C1b		9.20E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
B6	N/A	79	16.850	17.448	0.598	-96.15	-96.77	69.24	11.41	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	C1b	0.210	0.260	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
C1	OSP	60	0.000	1.864	1.864	-93.78	-95.07	134.36	7.21	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.000	3.000	C1b	0.5	7.22E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
C2	60	70	1.864	3.727	1.863	-94.55	-96.32	N/A	N/A		S1	0.200	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
C3	70	N/A	3.727	5.037	1.310	-95.93	-96.40	N/A	N/A		S1	0.230	2.410	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
C3	N/A	77	5.037	5.591	0.554	-95.52	-96.16	N/A	N/A		S1	0.230	0.260	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
C4	77	N/A	5.591	6.231	0.640	-95.29	-95.57	N/A	N/A		S1	0.210	0.870	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
C4	N/A	84	6.231	7.454	1.223	-92.70	-95.48	N/A	N/A		S1	0.090	2.520	C1b		3.56E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
C5	84	91	7.454	9.318	1.864	-92.87	-95.44	272.86	14.63		S1	0.160	0.450	C1b		7.97E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
D1	OSP	59	0.000	1.864	1.864	-93.79	-95.97	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.000	3.000	C1b	0.5	3.61E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
D2	59	69	1.864	3.727	1.863	-95.17	-96.21	N/A	N/A		S1	0.200	3.000	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for majority of section may reduce burial depth or require multiple passes when jetting.	
D3	69	76	3.727	5.591	1.864	-95.41	-96.34	N/A	N/A		S1	0.230	3.000	C1b		2.17E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A			Short section of Coal Pit stiff clays within burial profile from KP1.864 to KP3.95	
D4	76	83	5.591	7.454	1.863	-94.12	-96.11	N/A	N/A		S1	0.210	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
D5	83	90	7.454	9.318	1.864	-94.73	-95.31	132.30	7.10		S1	0.170	0.750	C1b		5.44E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
E1	OSP	58	0.000	3.228	3.228	-93.77	-96.66	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.000	3.000	C1b	0.5	1.81E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
E2	58	N/A	3.228	3.737	0.509	-96.31	-96.80	N/A	N/A		S1	0.230	0.460	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
E2	N/A	N/A	3.737	4.464	0.727	-95.83	-96.32	N/A	N/A		S1	0.210	0.280	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
E2	N/A	68	4.464	5.091	0.627	-96.29	-96.95	N/A	N/A		S1	0.360	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
E3	68	75	5.091	6.955	1.864	-95.03	-97.01	N/A	N/A		S1	0.210	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
E4	75	89	6.955	10.183	3.228	-95.11	-95.85	N/A	N/A		S1	0.220	3.000	C1b		2.72E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
F1	OSP	57	0.000	4.930	4.930	-93.77	-97.14	N/A	N/A		S1	0.000	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
F2	57	56	4.930	6.794	1.864	-95.90	-96.30	N/A	N/A		S1	0.250	1.510	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
F3	56	66	6.794	8.658	1.864	-94.99	-96.15	N/A	N/A		S1	0.370	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				

Cable	WTG From	WTG To	KP Start (String)	KP End (String)	Section Length (km)	Water Depth (mLAT)		Missing Bathymetry		Seabed Composition At Target Depth of Lowering	GM Ground Model				CBRA Results				Burial Recommendations							Comments
						Min	Max	Combined length (m)	%-age missing		Layer 1	Min Base of Layer 1 (mBSB)	Max Base of Layer 1 (mBSB)	Layer 2	Recommended Depth of Lowering (m)	Pstrike at Recommended DOL	Strike Return Period (Years)	DNV Risk Category	Jetting	Ploughing	Mechanical Cutting	Burial Class	Remedial Protection (m)	Assumed Rock volume for remedial protection (m^3)	Key Risks in Zone	
F4	66	74	8.658	10.521	1.863	-95.07	-95.47	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.550	3.000	C6	0.5	2.06E-09	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for majority of section may reduce burial depth or require multiple passes when jetting.	
F5	74	N/A	10.521	11.387	0.866	-94.99	-95.20	N/A	N/A		S1	0.350	2.220	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
F5	N/A	82	11.387	12.385	0.998	-94.97	-95.22	N/A	N/A		S1	0.650	1.770	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
F6	82	67	12.385	15.613	3.228	-95.04	-95.83	N/A	N/A		S1	0.260	3.000	C1b		2.44E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A			Short section of Coal Pit stiff clays within burial profile from KP12.98 to KP13.1	
G1	OSP	N/A	0.000	3.900	3.900	-93.77	-97.21	251.02	6.44	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	-0.480	3.000	C1b	0.5	2.24E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
G1	N/A	N/A	3.900	8.507	4.607	-95.67	-96.59	N/A	N/A		S1	0.270	3.000	C6		1.47E-09	>1,000,000	1	Suitable	Possible	Not Suitable	B	500	1,834.93	Coal Pit stiff clays intermittently present within burial profile for majority of section may reduce burial depth or require multiple passes when jetting.	Crossing with Culzean 22" gas export pipeline at KP7.040
G1	N/A	45	8.507	10.125	1.618	-95.37	-96.00	651.54	40.14		S1	0.280	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
G2	45	54	10.125	11.988	1.863	-96.53	-96.90	1665.53	89.35		S1	0.280	0.400	C1b		3.98E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
G3	54	65	11.988	13.855	1.867	-95.18	-96.60	785.48	42.06		S1	0.210	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
G4	65	55	13.855	15.718	1.863	-95.41	-96.53	N/A	N/A		S1	3.000	3.000	S1		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
H1	OSP	38	0.000	3.228	3.228	-93.10	-94.76	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.000	0.670	C1b	0.5	3.24E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
H2	38	28	3.228	5.091	1.863	-94.74	-96.43	N/A	N/A		S1	0.350	3.000	C1b		2.55E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
H3	28	37	5.091	6.955	1.864	-96.14	-96.66	N/A	N/A		S1	0.680	3.000	C1b		1.67E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
H4	37	47	6.955	8.818	1.863	-96.00	-96.77	N/A	N/A		S1	0.210	3.000	C6		9.42E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A			Short section of Coal Pit stiff clays within burial profile from KP8.25 to KP8.5	
H5	47	48	8.818	10.682	1.864	-95.96	-97.01	N/A	N/A		S1	0.490	3.000	C1b		5.23E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
H6	48	49	10.682	12.546	1.864	-94.00	-97.14	N/A	N/A		S1	0.150	3.000	C1b		2.36E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
I1	OSP	19	0.000	7.478	7.478	-92.51	-98.95	227.31	3.04	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.000	3.000	C1b	0.5	7.1136E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A	500	1,834.93		Crossing with Culzean 22" gas export pipeline at KP6.240
I2	19	27	7.478	9.341	1.863	-96.52	-98.92	N/A	N/A		S1	0.220	3.000	C1b		9.286E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
I3	27	36	9.341	11.204	1.863	-96.62	-97.54	N/A	N/A		S1	0.200	3.000	C1b		2.74E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
I4	36	46	11.204	13.067	1.863	-96.08	-96.74	N/A	N/A		S1	0.230	3.000	C1b		8.3688E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
I5	46	35	13.067	14.933	1.866	-95.88	-97.98	590.13	31.60		S1	0.230	3.000	C1b		6.2107E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
I6	35	26	14.933	16.797	1.864	-96.10	-97.87	N/A	N/A		S1	0.400	3.000	C1b		8.6901E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
J1	OSP	39	0.000	1.864	1.864	-92.18	-94.95	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.270	0.730	C1b	0.5	2.36E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
J2	39	29	1.864	3.727	1.863	-94.64	-96.66	N/A	N/A		S1	0.400	3.000	C1b		3.29E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
J3	29	20	3.727	5.591	1.864	-96.28	-98.07	N/A	N/A		S1	0.250	3.000	C1b		4.08E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
J4	20	12	5.591	8.234	2.643	-97.44	-98.59	232.51	8.79		S1	0.260	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A	500	1,834.93		Crossing with Culzean 22" gas export pipeline at KP6.920
J5	12	11	8.234	10.099	1.865	-97.98	-99.75	475.18	25.47		S1	0.200	3.000	C1b		4.02E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
J6	11	18	10.099	11.962	1.863	-97.95	-99.68	N/A	N/A		S1	0.200	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
K1	OSP	6	0.000	10.262	10.262	-92.37	-99.78	672.82	6.55	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.180	3.000	C1b	0.5	7.80E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A	500	1,834.93		Crossing with Culzean 22" gas export pipeline at KP7.230
K2	6	7	10.262	12.127	1.865	-98.18	-99.80	518.63	27.80		S1	0.460	0.730	C1b		2.87E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
K3	7	3	12.127	13.990	1.863	-97.15	-98.33	N/A	N/A		S1	0.200	0.800	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
K4	3	1	13.990	15.853	1.863	-97.26	-100.11	167.36	8.98		S1	0.150	3.000	C1b		7.14E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
L1	OSP	30	0.000	3.228	3.228	-92.58	-97.43	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.250	3.000	C1b	0.5	4.879E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
L2	30	21	3.228	5.091	1.863	-97.05	-98.17	N/A	N/A		S1	0.230	3.000	C1b		7.31E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
L3	21	13	5.091	6.955	1.864	-96.87	-97.99	N/A	N/A		S1	0.200	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
L4	13	8	6.955	8.818	1.863	-97.14	-98.26	N/A	N/A		S1	0.240	3.000	C1b		4.18E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
L5	8	4	8.818	10.682	1.864	-97.15	-97.80	N/A	N/A		S1	0.320	3.000	C1b		4.18E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
M1	OSP	40	0.000	1.864	1.864	-93.03	-95.94	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.270	0.680	C1b	0.5	5.05E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
M2	40	22	1.864	5.091	3.227	-95.66	-97.67	N/A	N/A		S1	0.210	3.000	C1b		1.84E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
M3	22	14	5.091	6.955	1.864	-96.53	-97.30	N/A	N/A		S1	0.180	0.680	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
M4	14	9	6.955	8.818	1.863	-96.36	-97.32	N/A	N/A		S1	0.450	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
M5	9	2	8.818	12.046	3.228	-95.03	-96.89	N/A	N/A		S1	0.230	3.000	C1b		8.37E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
N1	OSP	31	0.000	3.906	3.906	-93.36	-96.40	N/A	N/A		S1	0.270	3.000	C1b		4.68E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				

						Water Depth (mLAT)		Missing Bathymetry			GM Ground Model				CBRA Results				Burial Recommendations							
Cable	WTG From	WTG To	KP Start (String)	KP End (String)	Section Length (km)	Min	Max	Combined length (m)	%-age missing	Seabed Composition At Target Depth of Lowering	Layer 1	Min Base of Layer 1 (mBSB)	Max Base of Layer 1 (mBSB)	Layer 2	Recommended Depth of Lowering (m)	Pstrike at Recommended DOL	Strike Return Period (Years)	DNV Risk Category	Jetting	Ploughing	Mechanical Cutting	Burial Class	Remedial Protection (m)	Assumed Rock volume for remedial protection (m^3)	Key Risks in Zone	Comments
N2	31	23	3.906	5.769	1.863	-96.17	-97.07	N/A	N/A	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.130	3.000	C1b	0.5	2.04E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
N3	23	15	5.769	7.633	1.864	-96.23	-96.91	N/A	N/A		S1	0.180	2.620	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
N4	15	10	7.633	9.496	1.863	-95.56	-96.44	N/A	N/A		S1	1.930	3.000	C1b		3.09E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
N5	10	5	9.496	11.360	1.864	-95.19	-95.64	N/A	N/A		S1	0.600	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
O1	OSP	41	0.000	3.228	3.228	-93.63	-96.84	248.96	7.71	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.220	0.760	C1b	0.5	7.87E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
O2	41	32	3.228	5.091	1.863	-95.75	-96.96	285.95	15.34		S1	0.290	3.000	C1b		2.04E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
O3	32	33	5.091	6.955	1.864	-94.14	-95.82	382.11	20.50		S1	3.000	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
O4	33	24	6.955	8.818	1.863	-94.35	-95.92	375.14	20.12		S1	0.380	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
O5	24	16	8.818	10.682	1.864	-95.17	-95.72	133.31	7.15		S1	0.420	2.430	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P1	16	42	0.000	4.930	4.930	-93.71	-96.36	558.78	11.33	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.230	3.000	C1b	0.5	8.16E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P2	42	43	4.930	6.794	1.864	-95.45	-95.95	191.75	10.29		S1	3.000	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P3	43	62	6.794	8.658	1.864	-91.96	-95.61	324.60	17.40		S1	0.340	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P4	62	34	8.658	10.522	1.864	-91.94	-93.63	310.03	16.63		S1	0.120	3.000	C1b		5.27E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P5	34	25	10.522	12.385	1.863	-93.24	-94.99	210.82	11.31		S1	0.170	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
P6	25	17	12.385	14.249	1.864	-94.13	-95.54	391.50	21.00		S1	0.250	1.670	C1b		8.37E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q1	OSP	50	0.000	1.864	1.864	-93.77	-95.84	117.58	6.31	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.200	1.060	C1b	0.5	0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q2	50	51	1.864	3.727	1.863	-95.62	-96.33	379.32	20.35		S1	0.220	0.490	C1b		5.89E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q3	51	52	3.727	5.591	1.864	-95.56	-96.93	163.76	8.78		S1	0.260	3.000	C1b		8.30E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q4	52	N/A	5.591	6.365	0.774	-96.51	-97.20	88.88	11.51		S1	0.310	3.000	C1b		1.02E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q4	N/A	63	6.365	7.454	1.089	-96.11	-96.61	169.49	15.52		S1	0.310	0.480	C6		2.16E-09	>1,000,000	1	Suitable	Possible	Not Suitable	B			Coal Pit stiff clays present within burial profile for whole section may reduce burial depth or require multiple passes when jetting.	
Q5	63	N/A	7.454	7.862	0.408	-95.78	-96.47	2.80	0.69	Sands with thin clay layers (FHW) and clay with thin sand layers (FHF)	C1b	0.350	1.680	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				Coal Pit formation not present within burial profile
Q5	N/A	N/A	7.862	8.568	0.706	-95.51	-95.92	81.18	11.51	Clayey silty sand, with occasional gravel and isolated to scattered cobbles and boulders	S1	0.280	2.690	C6		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	B			Short section of Coal Pit stiff clays within burial profile from KP8.3 to KP8.4	
Q5	N/A	64	8.568	9.318	0.750	-94.94	-95.67	100.78	13.38		S1	0.380	3.000	C1b		0.00E+00	>1,000,000	1	Suitable	Possible	Not Suitable	A				
Q6	64	73	9.318	11.181	1.863	-94.59	-95.42	294.53	15.80		S1	0.360	3.000	C1b		3.47E-09	>1,000,000	1	Suitable	Possible	Not Suitable	A				