LBA CCS TRANSPORT AND STORAGE PROJECT

POINT OF AYR TO SATELLITE PLATFORMS

OFFSHORE CABLES PRELIMINARY CROSSING DESIGN REPORT

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HOLD RECORD

1.	Geotechnical and Geophysical survey reports

ASSUMPTIONS RECORD

1.	Crossing at the proximity of Douglas CCS platform to be confirmed based on decommission of existing cables/pipelines and to be verified further with the De-commissioning scope for the project.

Contents

1.0 INTRODUCTION

1.1 Project Overview

Refer to Offshore Project Basis of Design, document 1025H0BGRB09002 [Ref.1].

1.2 Purpose and Scope

The scope of this document is to identify the number of cable crossings and present a suitable crossing design for the new offshore power cables in the LBA CCS Transport and Storage Project. The new power cables within the scope of this document are shown in Figure 1-1 and includes:

- Power Cable (2 Nos.) from Point of Ayr to Douglas CCS Platform
- Power Cable from Douglas CCS Platform to Hamilton North Platform
- Power Cable from Douglas CCS Platform to Lennox Platform
- Power Cable from Douglas CCS Platform to Hamilton Main Platform

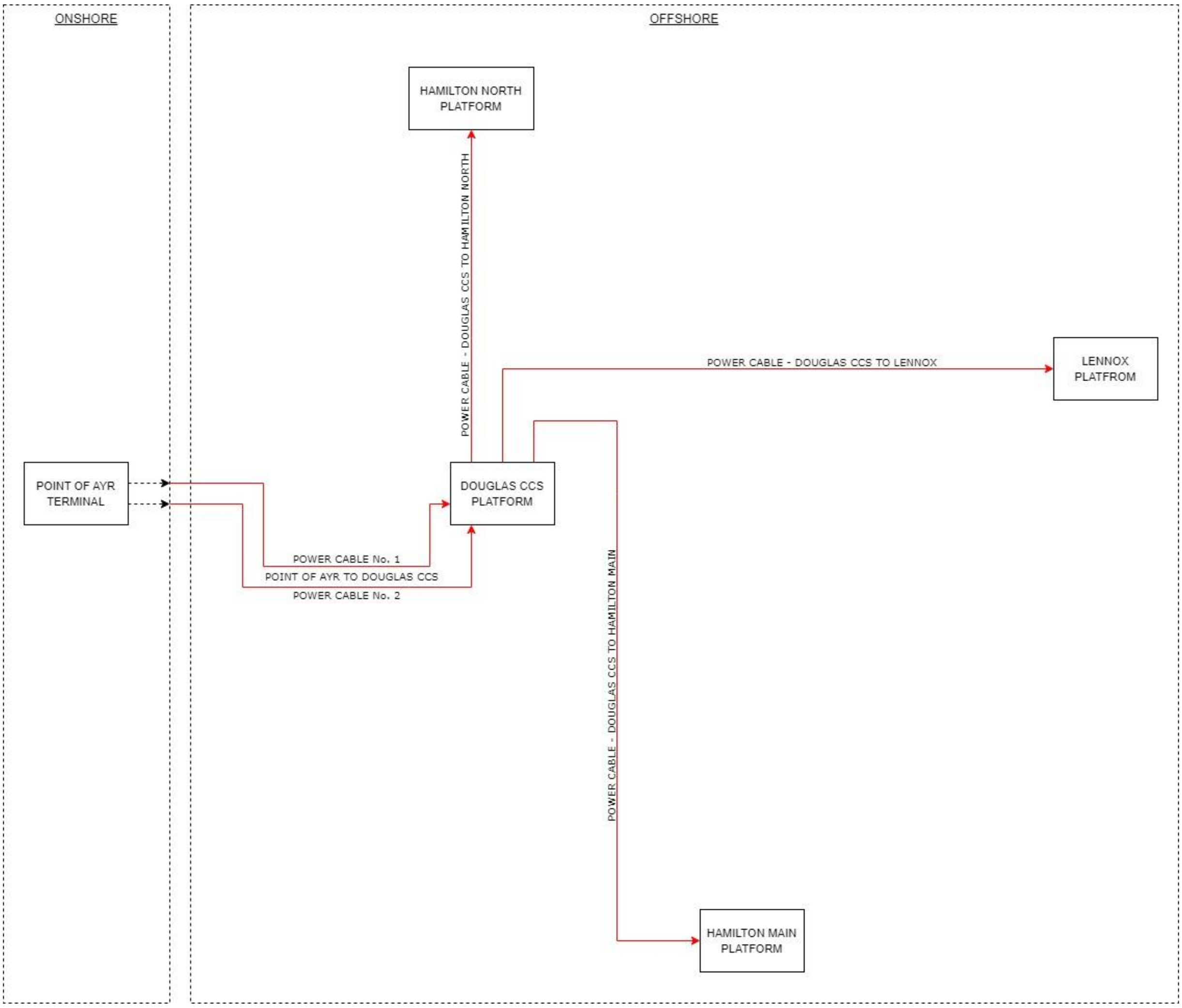

Figure 1-1: Offshore Power Cables Simplified Schematic

2.0 BATTERY LIMITS

The battery limits covering the offshore cables are defined as follows:

Outside Diameter Nominal Size	Description	From	To
150mm	Power Cable	Point of Ayr (Nearshore)	J-tube Douglas CCS
150mm	Power Cable	J-tube Douglas CCS	J-tube Hamilton North
150mm	Power Cable	J-tube Douglas CCS	J-tube Hamilton Main
150mm	Power Cable	J-tube Douglas CCS	J-tube Lennox

Table 2-1 – Battery Limit

3.0 DEFINITIONS AND ABBREVIATIONSLL

3.1 Definitions

The following definitions, terminology and abbreviations are applicable for the Project and used throughout this document:

COMPANY/CLIENT	The party that initiates the project and ultimately pays for its design and construction i.e., Eni UK. The COMPANY/CLIENT will generally specify technical requirements. The term "COMPANY/CLIENT" also includes agents or consultants authorized to act for and on behalf of COMPANY/CLIENT. Eni UK is the Client for LBA CCS Transport and Storage
CONTRACTOR	A person or organisation that undertakes responsibility for the execution of a CONTRACT. EniProgetti is responsible for execution of the Scope of work agreed with the COMPANY/CLIENT
CONTRACT	An acceptance of legal relations between two or more parties for the transfer of goods or services for value.
Project or Plant:	LBA CCS Transport and Storage
WORK	shall mean all work that CONTRACTOR is required to carry out in accordance with the provisions of CONTRACT including all related services and resources to be provided in accordance with the CONTRACT
SHALL	A mandatory provision
Should	An advisory provision

3.2 Abbreviations

ALARP	As Low As Reasonably Practicable
CCS	Carbon Capture and Storage
DNV	Det Norske Veritas
FEED	Front-End Engineering Design
HVDC	High Voltage Direct Current
LBA	Liverpool Bay Asset
MTPA	Million Ton Per Annum
N/A	Not Applicable
Nos.	Numbers
OLU	Offshore Loading Unit
OSI	Offshore Storage Installation
W.D.	Water Depth

4.0 REFERENCES

For all the applicable project documents, ENI company standards and international standards intend to be used for FEED engineering activities, refer to Project List of Applicable Codes and Standards [Ref.2].

4.1 Project Documents

[Ref.1] 1025H0BGRB09002 Basis of Design Offshore 4.5 MTPA (Gas Phase) – FEED &10 MTPA (Dense Phase) – Feasibility
[Ref.2] 102100BESB09003 Project List of Applicable Codes and Standards
[Ref.3] 1025H0BSDG84104 New Offshore Power Cable and Fibre Optic Field Layout
[Ref.4] 1023DSBSRV84183 Offshore Cable Preliminary Routing Report
[Ref.5] 1025H0BSRA84106 Offshore Subsea Cable Stability Study
[Ref.6] 1025H0BSRV84107 Offshore Power Cable Protection Requirement
[Ref.7] 1025H0BSSA84108 Power Cable Installation Specification
[Ref.8] 1025H0BSSA84109 Offshore Power Cable Trenching and Backfilling Specification
[Ref.9] 1025H0BSDN84112 Offshore Power Cable - Approach Drawings
[Ref.10] 1023DSBSDG84178 Typical Power Cable crossing Existing Pipeline on Seabed
[Ref.11] 1023DSBSDG84179 Typical Power Cable crossing Existing Pipeline Buried
[Ref.12] 1023DSBSDG84180 Typical Power Cable crossing Existing Cable on Seabed
[Ref.13] 1023DSBSDG84181 Typical Power Cable crossing Existing Cable Buried

4.2 COMPANY/CLIENT Specifications

COMPANY/CLIENT Specifications to comply with [Ref.2].

[Ref.14] 23025.ENG.PLI.PRG Design of Offshore Pipelines
[Ref.15] 23015.ENI.PLI.STD Pre-Construction Marine Survey
[Ref.16] 23009.ENG.PLI.STD Purchase and Installation of Flexible Mattresses to Protect, Stabilise and Support Offshore Pipelines
[Ref.17] 23008.ENG.PLI.STD Purchase and Installation of Rock dump over Offshore Pipelines for Intervention Purposes

4.3 International Codes and Standards

International Codes and Standards to comply with [Ref.2].

[Ref.18] DNV-ST-F101 Submarine Pipeline System
[Ref.19] DNV-RP-0360 Offshore Power Cables in Shallow Water
[Ref.20] ISO 13628-5 Petroleum and natural gas industries – Design and operation of Offshore production systems – Part 5: Offshore Cables

4.4 Others

External Survey Reports
(Hold 1)

[Ref.21] GMS-GYME-PL-3012 GWYNT-Y-MÔR Offshore Wind Farm Installation of Subsea Power & Optical Fibre Composite 132kv Export Cables Report
[Ref.22] CWY-KWL-PPL-REP-10005 Burbo Bank Extension / BBW02 ENI Pipeline Crossing and Protection Procedure

4.5 Order of Precedence

Should conflict arise between the statements of different rules, codes or standards, the following list of precedence SHALL be respected:

1. Law and National Standards
2. Design Basis, Project Specifications and Drawings
3. COMPANY/CLIENT Specifications
4. International Codes and Standards

If conflicts arise the most stringent requirement SHALL apply in its entirety of the specific topic. In all cases of conflict, the COMPANY/CLIENT SHALL be informed.

5.0 SUMMARY AND RECOMMENDATION

5.1 Summary

The total number of 27 crossings identified in this report are based on the latest LBA CCS New Offshore Power Cable and Fibre Optic Field Layout [Ref.3] and Offshore Cable Preliminary Routing Report [Ref.4]. The crossing length identified in Table 5-1 below has been taken from the Offshore Power Cable and Fibre Optic Field Layout drawing [Ref.3].

Crossing ID	LBA CCS Power Cable	Pipeline/Cable to be Crossed	Crossing length (m)	Asset Owner / Operator
PoAX-1	Power Cable (2 Nos.) from Point of Ayr to Douglas CCS Platform	Burbo Bank Wind Farm Cable	-	Ørsted
PoAX-2		North Hoyle Wind Farm (Export Cable)	14 Note 1	Greencoat UK Wind
PoAX-3		North Hoyle Wind Farm (Export Cable)		
PoAX-4		Gwynt y Môr Wind Farm (Export Cable)	50 Note 1	Gwynt y Môr OFTO
PoAX-5		Gwynt y Môr Wind Farm (Export Cable)		
PoAX-6		Gwynt y Môr Wind Farm (Inter Array Cable)	-	
PoAX-7		Western Link HVDC Cable - Pole 1	30 Note 1	National Grid plc / Scottish Power Transmission
PoAX-8		Western Link HVDC Cable - Pole 2		
PoAX-9		Existing 2 x 3" Condensate (PL1032 + 1033) to PoA	13 Note 1	Eni UK
PoAX-10		Existing 20" Gas (PL 1030) to PoA		
DHNX-1	Power Cable from Douglas CCS Platform to Hamilton North Platform	8" (PL 2939) Production to CONWY	40 Note 1	Eni UK
DHNX-2		3" (PL 2941) Condensate PL to CONWY		
DHNX-3		8" (PL 2940) Water Injection Pipeline to CONWY		
DHNX-4		14" (PL 1031) Oil Export to OSI	-	
DHNX-5		14" (PL 1041) Gas Export + 2" (PL 1042) Methanol Piggyback from Hamilton North	40 Note 1	
DHNX-6		Existing Power Cable to Hamilton North		
DLX-1	Power Cable from Douglas CCS Platform to Lennox Platform	8" (PL 2939) Production to CONWY	39 Note 1	Eni UK
DLX-2		3" (PL 2941) Condensate PL to CONWY		
DLX-3		8" (PL 2940) Water Injection Pipeline to CONWY		
DLX-4		14" (PL 1031) Oil Export to OSI	-	
DLX-5		14" Gas Export + 2" Methanol Piggyback from Hamilton North	47 Note 1	
DLX-6		Existing Power Cable to Hamilton North		
DHMX-1	Power Cable from Douglas CCS Platform to Hamilton Main Platform	14" (PL 1031) Oil Export to OSI	180 Note 1	Eni UK
DHMX-2		14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North		
DHMX-3		16" Gas Export (PL 1035) from Lennox		
DHMX-4		20" Gas export (PL 1039) + 2" Methanol (PL 1040) from Hamilton Main		
DHMX-5		12" Gas Injection (PL 1036A) to Lennox		
Note 1: Distance between the first and the furthest edges of cables in closed proximity to be crossed.				

Table 5-1 Summary of Crossings for the LBA CCS Offshore Power Cables

Section 7.0 of this report provides a description of the crossing design methodologies adopted for this project. The primary objective of crossing design is to protect the existing asset and maintain a minimum vertical separation of 0.3m between the existing line to be crossed and the power cable. To achieve the minimum vertical separation, a pre-lay concrete mattress is placed at the crossing location upon which the cable is laid. However, at the crossing location, cable burial is not feasible; therefore, cable at crossing location is to be protected by placing concrete mattresses or rock berm on top in accordance with Offshore Power Cable Protection Requirement [Ref.6].

An exemption to the above design methodology is applicable for the crossing DHMX-1, where the power cable is crossing with the 14" PL 1031 Oil Export Pipeline to OSI. The existing line (PL 1031) is being considered for decommissioning and removal in the near future. To facilitate this decommissioning activity, a concrete bridge support will be utilised for the crossing as described in section 7.1.3. The cable will be laid on the concrete bridge and protected with post lay concrete mattresses in accordance with Offshore Power Cable Protection Requirement [Ref.6].

The Table 5-2, Table 5-3 and Table 5-4, provided below, summarises the recommended crossing designs.

Crossing ID	**Pre-Lay Protection**		**Post-Lay Protection**		
	Type	**Quantity (Nos.)**	**Type**	**Total Length (m)**	**Total Quantity / Volume (Nos. / m^3)**
PoAX-1	Concrete Mattress	1	Concrete Mattress	120m	20 Nos.
PoAX-6	Concrete Mattress	1	Rock Berm	112m	454m^3
DHNX-4	Concrete Mattress	1	Rock Berm	112m	454m^3
DLX-4	Concrete Mattress	1	Rock Berm	112m	454m^3
Note 1: It should be noted that protection requirements for the optional Power Cable No. 1 from Point of Ayr to Douglas CCS has not been considered for the calculation of quantities.					

Table 5-2 Single Crossing Design Summary

Crossing ID	**Pre-Lay Protection**		**Post-Lay Protection**		
	Type	**Quantity (Nos.)**	**Type**	**Total Length (m)**	**Total Quantity / Volume (Nos. / m^3)**
PoAX-2 & PoAX-3	Concrete Mattress	2	Concrete Mattress	138m	23 Nos.
PoAX-4 & PoAX-5	Concrete Mattress	2	Rock Berm	162m	654m^3
PoAX-7 & PoAX-8	Concrete Mattress	2	Rock Berm	131m	530m^3
PaAX-9 & PoAX-10	Concrete Mattress	2	Concrete Mattress	126m	21 Nos.
DHNX-1, DHNX-2 & DHNX-3	Concrete Mattress	2	Rock Berm	152m	614m^3
DHNX-5 & DHNX-6	Concrete Mattress	2	Rock Berm	158m	638m^3
DLX-1, DLX-2 & DLX-3	Concrete Mattress	2	Rock Berm	151m	610m^3
DLX-5 & DLX-6	Concrete Mattress	2	Rock Berm	159m	642m^3
Note 1: It should be noted that protection requirements for the optional Power Cable No. 1 from Point of Ayr to Douglas CCS has not been considered for the calculation of quantities.					

Table 5-3 Multiple Crossing Design Summary

<table>
<tr><th rowspan="2">Crossing ID</th><th colspan="2">Pre-Lay Protection</th><th colspan="3">Post-Lay Protection</th></tr>
<tr><th>Type</th><th>Quantity (Nos.)</th><th>Type</th><th>Total Length (m)</th><th>Total Quantity (Nos.)</th></tr>
<tr><td>DHMX-1</td><td>Concrete Bridge</td><td>1</td><td>Concrete Mattress</td><td rowspan="5">420m</td><td rowspan="5">70 Nos.[Note 1]</td></tr>
<tr><td>DHMX-2</td><td>Concrete Mattress</td><td>1</td><td>Concrete Mattress</td></tr>
<tr><td>DHMX-3</td><td>Concrete Mattress</td><td>1</td><td>Concrete Mattress</td></tr>
<tr><td>DHMX-4</td><td>Concrete Mattress</td><td>1</td><td>Concrete Mattress</td></tr>
<tr><td>DHMX-5</td><td>Concrete Mattress</td><td>1</td><td>Concrete Mattress</td></tr>
<tr><td colspan="6">Note 1: This concrete mattress quantity has already been included in the Offshore Power Cable Protection Requirement Report [Ref.6] as part of the platform approach protection requirement.</td></tr>
</table>

Table 5-4 Douglas CCS Platform Approach Crossing Design Summary

5.2 RECOMMENDATION

1. Crossing type, number, and length to reviewed based on any future cable route change or additional survey information.
2. Selection of concrete mattresses or rock-dump as post lay protection to be finalised during detail design phase based on Offshore Power Cable Protection Requirement [Ref.6].

6.0 CROSSING IDENTIFICATION

6.1 Assumptions

As a part of the decommissioning campaign, certain existing assets will undergo decommissioning. At this stage, the PL 1031 line is assumed to be in place while other assets will be considered decommissioned. However, this assumption shall be validated against the De-commissioning scope of existing assets at the Douglas Complex Location.

All the pipelines and cables identified to be crossed are assumed buried as documented in the referenced project.

6.2 Identified Crossings

The new power cable crossings are listed below.

6.2.1 Power Cable (2 Nos.) from Point of Ayr to Douglas CCS Platform Crossings

The two proposed power cables cross over eight (8) existing power cables and two (2) existing pipelines. All cables and pipelines identified to be crossed are assumed not exposed on seabed but are still buried as documented in the referenced project reports. Below is the list of the cable crossings:

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
PoAX-1	Burbo Bank Wind Farm Cable	470982.10	5916031.50	5m	Ørsted
PoAX-2	North Hoyle Wind Farm (Export Cable)	468802.92	5916564.54	7m	Greencoat UK Wind
PoAX-3	North Hoyle Wind Farm (Export Cable)	468784.06	5916566.12	7m	
PoAX-4	Gwynt y Môr Wind Farm (Export Cable)	461926.24	5917785.34	12m	Gwynt y Môr OFTO
PoAX-5	Gwynt y Môr Wind Farm (Export Cable)	461898.51	5917837.67	12m	
PoAX-6	Gwynt y Môr Wind Farm (Inter Array Cable)	461743.35	5924702.50	20m	
PoAX-7	Western Link HVDC Cable – Pole 1	461743.35	5930783.12	30m	National Grid / Scottish Power
PoAX-8	Western Link HVDC Cable – Pole 2	461743.35	5930814.39	30m	
PoAX-9	Existing 2 x 3” Condensate (PL 1032 + 1033) to PoA	461762.79	5932068.87	28m	Eni UK
PoAX-10	Existing 20” Gas (PL 1030) to PoA	461751.39	5932074.01	28m	
Note 1: Based on Offshore Coordinate System, [Ref.4]					

Table 6-1 Identified Crossing Details of Power Cable No. 1 from Point of Ayr to Douglas CCS Platform

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
PoAX-1	Burbo Bank Wind Farm Cable	470974.84	5916002.39	5m	Ørsted
PoAX-2	North Hoyle Wind Farm (Export Cable)	468795.03	5916535.10	7m	Greencoat UK Wind
PoAX-3	North Hoyle Wind Farm (Export Cable)	468776.17	5916536.68	7m	
PoAX-4	Gwynt y Môr Wind Farm (Export Cable)	461904.20	5917763.30	12m	Gwynt y Môr OFTO
PoAX-5	Gwynt y Môr Wind Farm (Export Cable)	461875.07	5917817.57	12m	
PoAX-6	Gwynt y Môr Wind Farm (Inter Array Cable)	461713.35	5924702.50	20m	
PoAX-7	Western Link HVDC Cable – Pole 1	461713.35	5930787.10	30m	National Grid / Scottish Power
PoAX-8	Western Link HVDC Cable – Pole 2	461713.35	5930818.38	30m	

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
PoAX-9	Existing 2 x 3" Condensate (PL 1032 + 1033) to PoA	461757.62	5932038.30	28m	Eni UK
PoAX-10	Existing 20" Gas (PL 1030) to PoA	461747.58	5932042.82	28m	
Note 1: Based on Offshore Coordinate System, [Ref.4]					

Table 6-2 Identified Crossing Details of Power Cable No. 2 from Point of Ayr to Douglas CCS Platform

Crossing ID	Pipeline/Cable to be Crossed	Crossing Angle (degree)	Crossing Type / Length (m)	Installed Status
PoAX-1	Burbo Bank Wind Farm Cable	89º	Single	Buried to 1.65m depth
PoAX-2	North Hoyle Wind Farm (Export Cable)	80º	Multiple / 14m Note 1	Buried to 1.50m depth
PoAX-3	North Hoyle Wind Farm (Export Cable)	80º		
PoAX-4	Gwynt y Môr Wind Farm (Export Cable)	74º	Multiple / 50m Note 1	Buried to 1.65m depth
PoAX-5	Gwynt y Môr Wind Farm (Export Cable)	74º		
PoAX-6	Gwynt y Môr Wind Farm (Inter Array Cable)	90º	Single	Buried to 1.65m depth
PoAX-7	Western Link HVDC Cable – Pole 1	82º	Multiple / 30m Note 1	Buried to 2.00m depth
PoAX-8	Western Link HVDC Cable – Pole 2	82º		
PoAX-9	Existing 2 x 3" Condensate (PL 1032 + 1033) to PoA	75º	Multiple / 13m Note 1	Buried to 0.80m depth
PoAX-10	Existing 20" Gas (PL 1030) to PoA	73º		Buried to 0.80m depth
Note 1: Distance between the first and the furthest edges of cables in closed proximity to be crossed.				

Table 6-3 Identified Crossing Details of Power Cable (2 Nos.) from Point of Ayr to Douglas CCS Platform

6.2.2 Power Cable from Douglas CCS Platform to Hamilton North Platform Crossings

The new proposed power cable cross existing pipelines from Douglas Platform to Offshore Loading Unit (OLU), Conwy and Hamilton North Platform. One cable crossing is also foreseen with the existing cable between Douglas Platform and Hamilton North. Below is the list of all crossings:

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
DHNX-1	8" (PL 2939) Production to CONWY	460909.46	5933939.93	26m	Eni UK
DHNX-2	3" (PL 2941) Condensate PL to CONWY	460909.49	5933940.04	26m	
DHNX-3	8" (PL 2940) Water Injection Pipeline to CONWY	460920.54	5933978.53	26m	
DHNX-4	14" Oil Export (PL 1031) to OSI	461482.09	5935104.25	28m	
DHNX-5	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	462068.24	5935289.42	28m	
DHNX-6	Existing Power Cable to Hamilton North	462112.27	5935303.33	28m	

Table 6-4 Identified Cable Crossing List of Power Cable from Douglas CCS Platform to Hamilton North Platform

Crossing ID	Pipeline/Cable to be Crossed	Crossing Angle (degree)	Crossing Type / Length (m)	Installed Status
DHNX-1	8" (PL 2939) Production to CONWY	49º	Multiple / 40m Note 1	Buried to 0.8m depth
DHNX-2	3" (PL 2941) Condensate PL to CONWY	49º		

Crossing ID	Pipeline/Cable to be Crossed	Crossing Angle (degree)	Crossing Type / Length (m)	Installed Status
DHNX-3	8" (PL 2940) Water Injection Pipeline to CONWY	48º		
DHNX-4	14" Oil Export (PL 1031) to OSI	68º	Single	Buried to 0.8m depth
DHNX-5	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	37º	Multiple / 46m Note 1	Buried to 0.8m depth
DHNX-6	Existing Power Cable to Hamilton North	37º		
Note 1: Distance between the first and the furthest edges of cables in closed proximity to be crossed.				

Table 6-5 Identified Crossing Details of Power Cable from Douglas CCS Platform to Hamilton North Platform

6.2.3 Power Cable from Douglas CCS Platform to Hamilton Main Platform Crossings

The new proposed power cable cross existing pipelines from Douglas Platform to Offshore Loading Unit (OLU), Conwy, Lennox, Hamilton North, and Hamilton Main Platform. Two cable crossings are also foreseen with the existing cable from Douglas Platform to Hamilton North and Hamilton Main Platform. Below are the list of all crossings:

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
DHMX-1	14" (PL 1031) Oil Export to OSI	461643.98	5932658.55	27m	Eni UK
DHMX-2	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	461659.25	5932678.96	27m	
DHMX-3	16" Gas Export (PL 1035) from Lennox	461699.91	5932733.30	27m	
DHMX-4	20" Gas export (PL 1039) + 2" Methanol (PL 1040) from Hamilton Main	461753.34	5932804.71	26.8m	
DHMX-5	12" Gas Injection (PL 1036A) to Lennox	461787.38	5932850.19	26.6m	

Table 6-6 Identified Cable Crossing List of Power Cable from Douglas CCS Platform to Hamilton Main Platform

Crossing ID	Pipeline/Cable to be Crossed	Crossing Angle (degree)	Crossing Type / Length (m)	Installed Status
DHMX-1	14" (PL 1031) Oil Export to OSI	79º	Multiple / 180m Note 1	Buried to 0.8m depth
DHMX-2	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	79º		Buried to 0.8m depth
DHMX-3	16" Gas Export (PL 1035) from Lennox	79º		Buried to 0.8m depth
DHMX-4	20" Gas export (PL 1039) + 2" Methanol (PL 1040) from Hamilton Main	72º		Buried to 0.8m depth
DHMX-5	12" Gas Injection (PL 1036A) to Lennox	67º		Buried to 0.8m depth
Note 1: Distance between the first and the furthest edges of cables in closed proximity to be crossed.				

Table 6-7 Identified Crossing Details of Power Cable from Douglas CCS Platform to Hamilton Main Platform

6.2.4 Power Cable from Douglas CCS Platform to Lennox Platform Crossings

The new proposed power cable cross existing pipelines from Douglas Platform to Offshore Loading Unit (OLU), Conwy and Hamilton North Platform. One cable crossing is also foreseen with the existing cable between Douglas Platform and Hamilton North. Below are the list of all crossings:

Crossing ID	Pipeline/Cable to be Crossed	UTM Coordinates		Water Depth (m)	Asset Owner / Operator
		Easting (m)	Northing (m)		
DLX-1	8" (PL 2939) Production to CONWY	460930.88	5933905.83	26m	Eni UK
DLX-2	3" (PL 2941) Condensate PL to CONWY	460931.03	5933906.36	26m	
DLX-3	8" (PL 2940) Water Injection Pipeline to CONWY	460941.84	5933944.00	26m	
DLX-4	14" Oil Export (PL 1031) to OLU	461479.34	5935071.92	28m	
DLX-5	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	462039.41	5935248.85	28m	
DLX-6	Existing Power Cable to Hamilton North	462084.05	5935262.96	28m	

Table 6-8 Identified Cable Crossing List of Power Cable from Douglas CCS Platform to Lenox Platform

Crossing ID	Pipeline/Cable to be Crossed	Crossing Angle (degree)	Crossing Type / Length (m)	Installed Status
DLX-1	8" (PL 2939) Production to CONWY	49º	Multiple / 39m Note 1	Buried to 0.8m depth
DLX-2	3" (PL 2941) Condensate PL to CONWY	49º		
DLX-3	8" (PL 2940) Water Injection Pipeline to CONWY	48º		Buried to 0.8m depth
DLX-4	14" Oil Export (PL 1031) to OLU	67º	Single	Buried to 0.8m depth
DLX-5	14" Gas Export (PL 1041) + 2" Methanol (PL 1042) from Hamilton North	37º	Multiple / 47m Note 1	Buried to 0.8m depth
DLX-6	Existing Power Cable to Hamilton North	38º		Buried to 0.8m depth
Note 1: Distance between the first and the furthest edges of cables in closed proximity to be crossed.				

Table 6-9 Identified Crossing Details of Power Cable from Douglas CCS to Lenox Platform

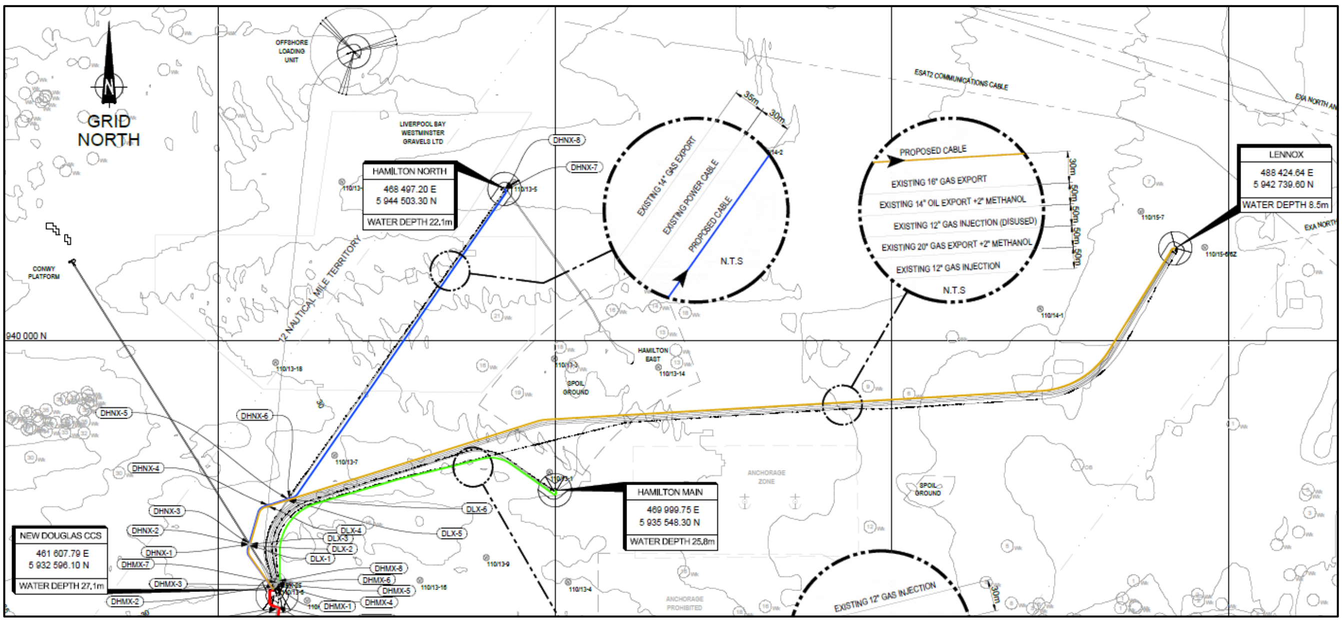

Figure 6-1 Crossings Identified on the Offshore Cable Field Layout for the Power Cable from Douglas CCS Platform to Hamilton Main, Hamilton North, and Lennox Platforms

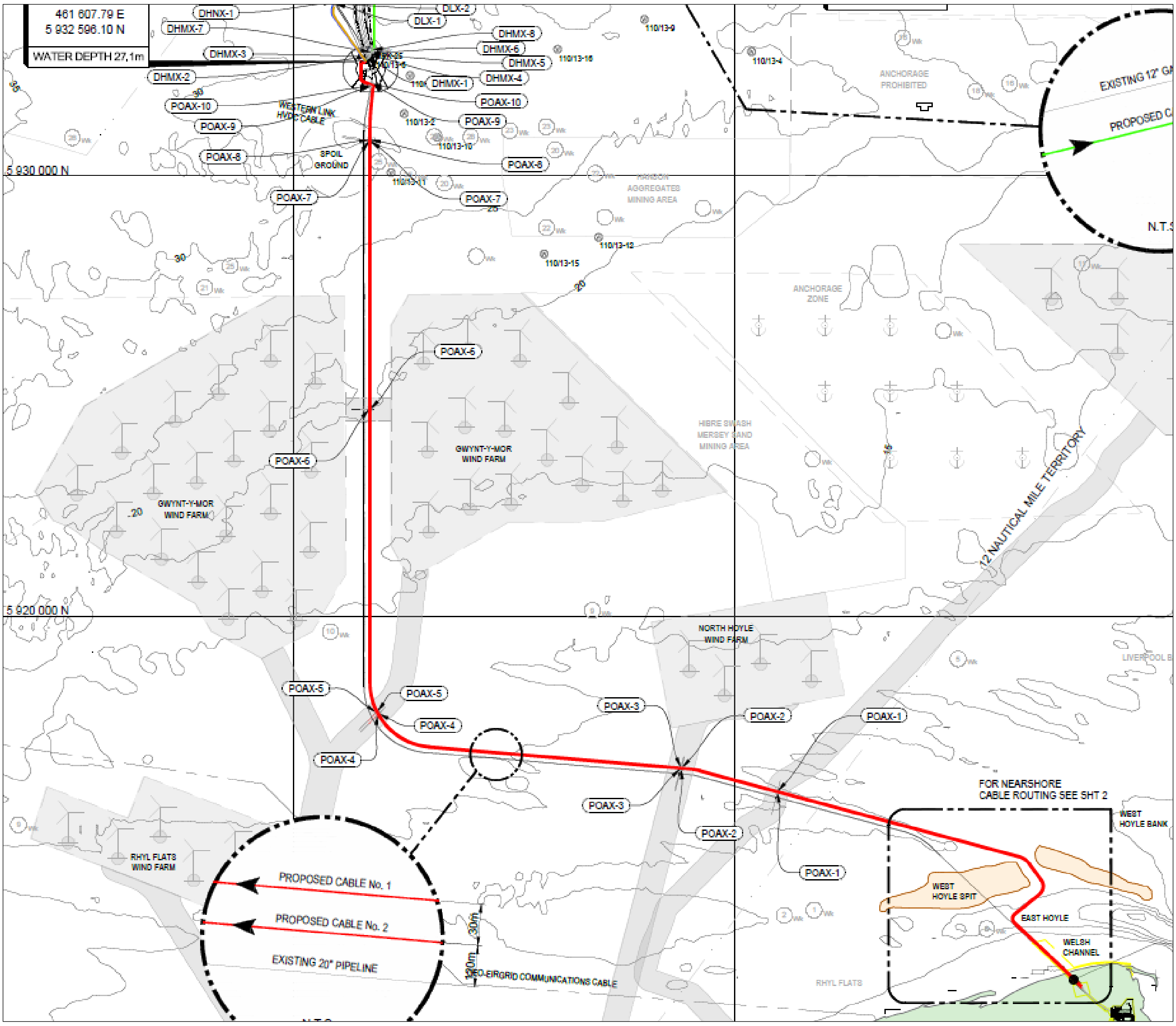

Figure 6-2 Crossings Identified on the Offshore Cable Field Layout for the Power Cable (2 Nos.) from Point of Ayr to Douglas CCS Platform

7.0 TYPICAL CROSSING METHODOLOGY

7.1 General

The new offshore cable crossing can be achieved by employing different methods, but this section will focus on three methodologies, and it has to be emphasised that the methodology to be used in offshore cable crossings in this project has to align with the offshore cable protection philosophy [Ref.6].

The crossing design methodologies discussed in this report are:

- Crossing with concrete mattresses;
- Crossing with concrete mattress and rock berm; and
- Crossing design with concrete bridge support and concrete mattresses.

As per the LBA CCS power cable design requirement [Ref.7] the minimum vertical separation between crossing existing line and power cable shall be 300mm.

7.1.1 Crossing with Concrete Mattress

The crossing with a concrete mattress involves placing a pre-lay concrete mattress on top of the existing line (if exposed) or above the buried line on the seabed to achieve the minimum vertical separation for crossings as stated above. The cable is then laid over the pre-laid concrete mattress. Sandbags may be used to support cable free spans if necessary, ensuring a smooth cable profile. Finally, post lay concrete mattresses are placed over the cable to protect the cable in accordance with the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

The Figure 7-1 below shows a typical schematic of crossing with concrete mattresses.

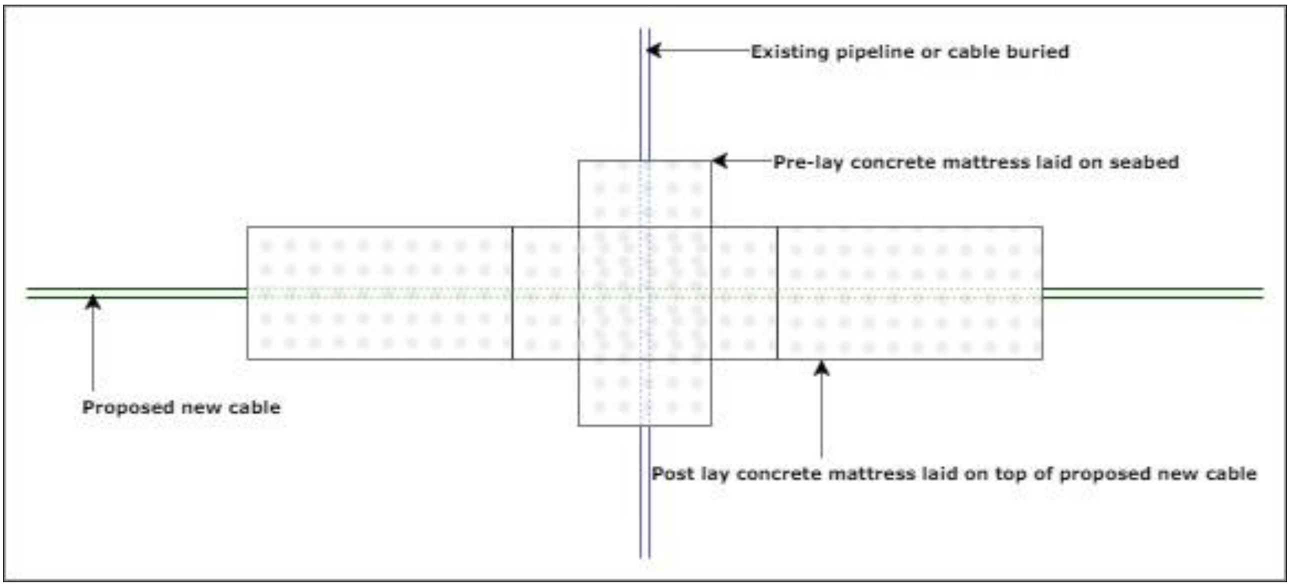

Figure 7-1 Typical Concrete Mattress Crossing

7.1.2 Crossing with Concrete Mattress and Rock Berm

The crossing with concrete mattress and rock berm involves placing a pre-lay concrete mattress on top of the existing line (if exposed) or above the buried line on the seabed to achieve the minimum vertical separation for crossings as stated above. The cable is then laid over the pre-laid concrete mattress. Sandbags may be used to support cable free spans if necessary, ensuring a smooth cable profile. Finally, post lay cable protection is achieved by using a rock berm, in accordance with the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

The Figure 7-2 below shows a typical schematic of crossing with concrete mattress and rock berm.

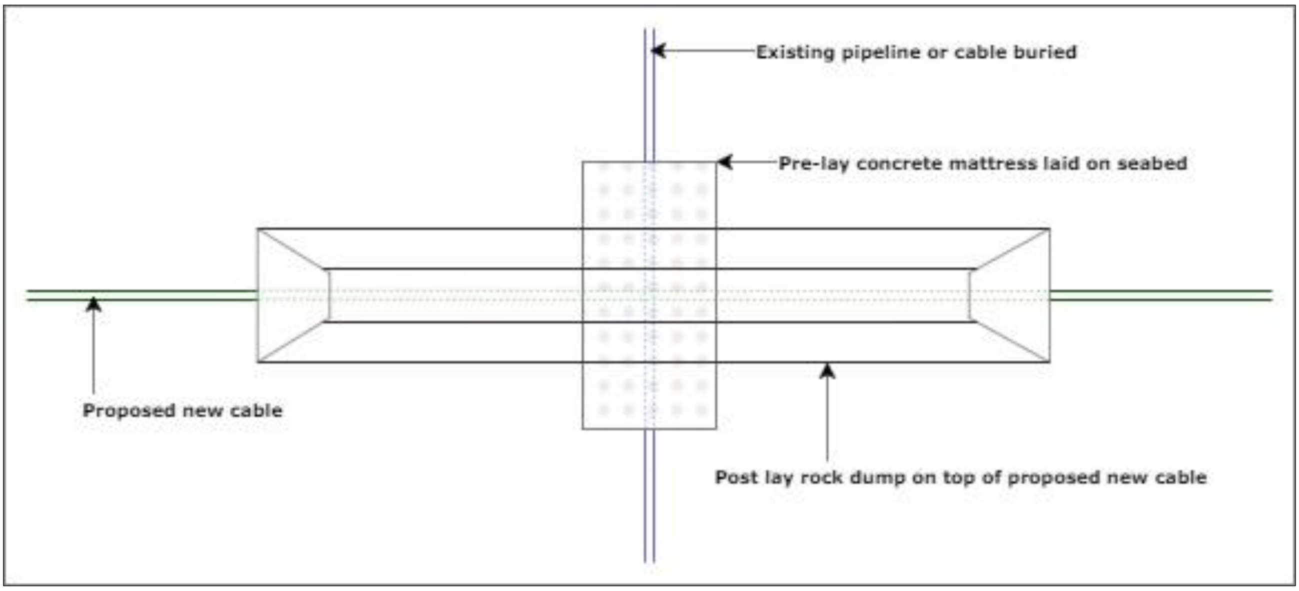

Figure 7-2 Typical Crossing with Concrete Mattress and Rock Berm

Rock installation to be performed in accordance with Offshore Power Cable Installation Specification [Ref.7]. For selection of rock sizes, details can be found in COMPANY Standard [Ref.17].

7.1.3 Crossing with Concrete Bridge Support and Concrete Mattresses

The concrete bridge-based crossing design provides a practical solution for situations where future access to assets beneath it is needed without causing any disruptions. As illustrated in the Figure 7-3, the bridge support has a middle section with through access, facilitating easy reach to the assets below. This accessibility is particularly advantageous for future scenarios when the line beneath the bridge may need to be decommissioned and removed. The crossing design is achieved by placing a concrete bridge support on seabed on top of the existing asset. The power cable is laid on top of the bridge structure to facilitate the crossing of the existing asset and also achieving a minimum vertical separation of 0.3m. To ensure post-lay protection, the cable is then covered with concrete mattresses in accordance with the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

Figure 7-3 Typical Concrete Bridge Support (Representative Image)

7.2 Crossing Requirements

The cable crossing must be designed to the following criteria:

- 25-year design life.
- Crossing should be made as near to a right angle (90 degrees) as possible. If a 90-degree crossing is not technically feasible then angles down to 45 degrees may be considered depending on the particular circumstances.
- No movement criterion- the cable crossing must have the capability to survive undamaged and stable at the installed position based on events with a 100-year return period.
- The proposed crossing design shall ensure that resulting load on the cable is within cable design parameters.
- The proposed methodology shall ensure a minimum vertical separation of 300mm is maintained between crossed lines.
- The proposed crossing design must not have any detrimental effect of the operational life of the cables that it is protecting.
- The design must be compliant with the requirements of the crossing agreement.
- The design shall include over-trawlability and protection against dragging anchors.

8.0 CONCRETE MATTRESS DESIGN REQUIREMENTS

8.1 Mattress Specification

The recommended mattress specification for crossing design of the cables is presented below:

Length	Width	Thickness	Density	Density Edge Block	Typ. Weight in Air	Typ. Weight in Water
[m]	[m]	[m]	[kg/m3]	[kg/m3]	[Tonnes]	[Tonnes]
6	3	0.3	2400	3600	10.08	6.62
Note 1: As per vendor specified data.						

Table 8-1 Recommended Mattress Specification

8.2 Design Features

The mattresses shall be designed to bend in two planes, by means of concrete blocks or units of suitable dimensions (length, breadth and height) and weight which are held together by ropes, to achieve the functionality requirements including but not limited to, structural strength, stability, flexibility, weight, etc.

As the mattresses shall be laid over and be in contact with the cable as shown in COMPANY approved Project Documents and Drawings, the mattress shall be designed to ensure that the minimum crush load of the cable is not exceeded after the mattress is installed over the cable.

Each mattress shall have adequate flexibility to conform to the profile of the seabed and/or cable onto which it is to be laid. The mattresses shall form a continuous profile giving an approximate semi-circular cross section shape with sufficient run out length on either side of the cable resting on the seabed. The flexibility of the mattresses shall be retained throughout the design life.

The mattresses shall be designed against abrasion by provision of neoprene coating of minimum thickness 3mm or approved equivalent. The mattresses shall be designed to retain their functionality and structural integrity for recovery at any time during the design life.

Each mattress shall incorporate permanent handling aids to permit easy installation and removal by a single crane with diver/ROV assistance. The permanent handling aids on each mattress shall be designed to withstand all anticipated loadings during all phases of the installation operations, including but not limited to, handling, transportation, lifting, installation, etc. Dynamic effects shall be considered in the design of permanent handling aids. Installation devices and handling aids shall not create snagging hazards for divers.

The density of the mattress shall be optimised within the overall size as specified in COMPANY approved Project Drawings. The mattress edge lift resistance shall be enhanced with a "Nose and Notch" or equivalent design subject to the approval of COMPANY.

8.3 Design Requirements for Stabilisation

The mattress shall be designed to ensure stability of both mattress and cable section covered by it. Mattress shall not be dislodged or displaced from its as-installed position when subject to environmental loadings anytime during the design life and, as a minimum, shall be designed for the two failure scenarios as follows:

- Stability Against Leading Edge; and
- Stability Against Sliding.

8.3.1 Stability Against Leading Edge Lift

Mattress shall not be lifted at the edge and rolled off the cable when subject to environmental loadings anytime during the design life.

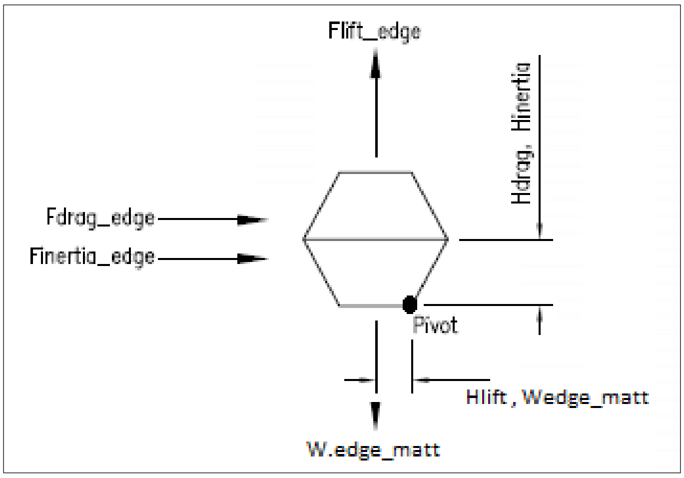

Figure 8-1 Hexagonal Block Forces Diagram

Moments at the pivot point must be satisfied for stability against edge lift and is expressed by:

$$(F_{drag\_edge} \cdot h_{drag} + F_{inertia\_edge} \cdot h_{inertia}) \leq (W_{SE} - F_{lift\_edge}) \cdot h_{lift}$$

Where,

W_{SE}	:	Submerged weight of the edge blocks per unit length along the mattress edge
F_{drag_edge}	:	Drag force acting on the block edge
$F_{inertia\_edge}$	:	Inertia force acting on the block edge
F_{lift_edge}	:	Lift force acting on the block edge
h_{drag}	:	Reference height for drag
$h_{inertia}$	:	Reference height for inertia
h_{lift}	:	Reference height for lift

8.3.2 Stability Against Sliding

The requirement to the mattress stability against sliding is expressed by:

$$F_H \leq \frac{\mu_m}{f_s}(W_{sm} - F_L)$$

Where,

F_H	:	Horizontal force
μ_m	:	Mattress to soil friction coefficient
f_s	:	Safety factor (min. of 1.1)
W_{sm}	:	Submerged weight of mattress per unit length
F_L	:	Lift force

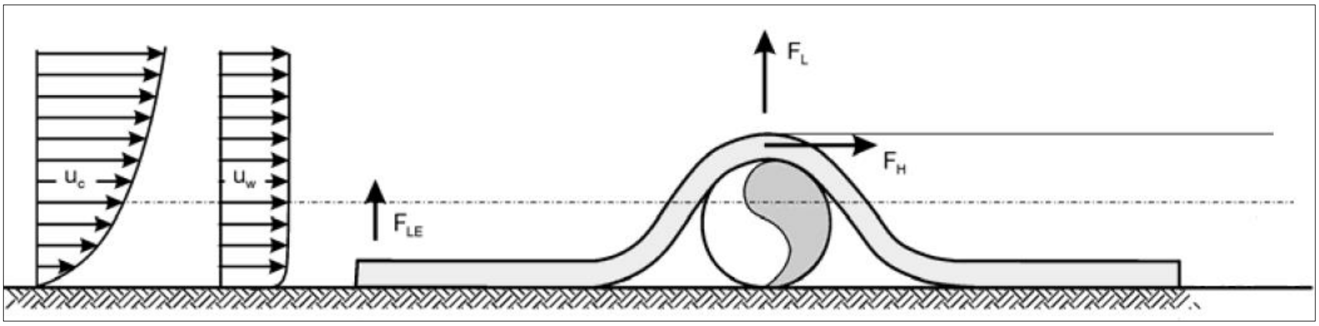

Figure 8-2 Mattress on the Cable - Definition of Parameters

8.4 Mattress Orientation / Placement

The mattress can be laid in two orientations as show in Figure 8-3. The length of the mattress depends upon the orientation in which it is laid, and the mattress length is always parallel to the cable. The final orientation shall be based on the mattress stability assessments and shall be confirmed during detailed design engineering by the CONTRACTOR using accurate metocean data for water depths.

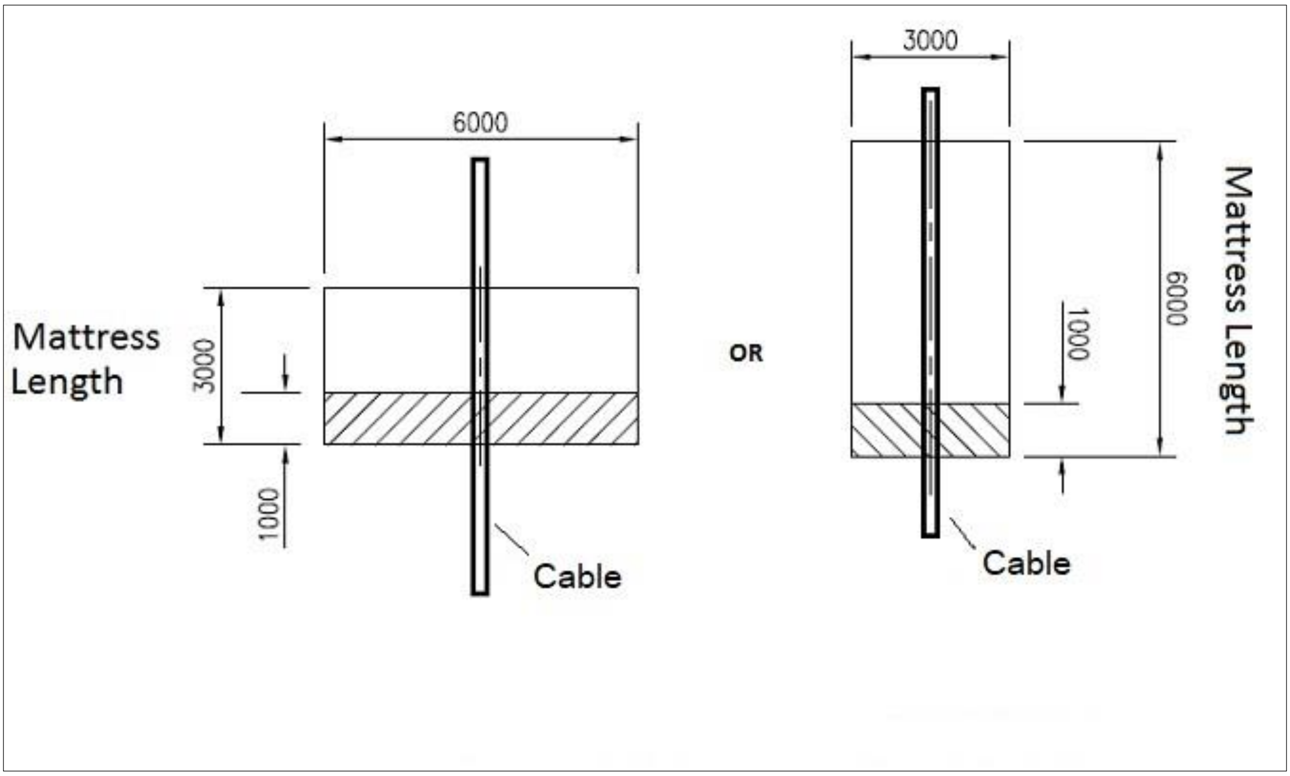

Figure 8-3 Mattress Orientation

After placement of mattress over the cable, the mattress shall maintain the cable in its initial as-laid position. The cable shall not be displaced from underneath the mattress such that it is no longer be covered by the mattress when subject to environmental loadings anytime during the design life.

Cable sections using mattresses as stabilisation measure shall satisfy the on-bottom stability criteria as specified in [Ref.5]. All cables will be buried during operation. The only chance for cables to be sitting on the seabed will be during installation (they might have been buried them as they install the cable - simultaneous installation), For all crossings other than those closed to each platform's cables will be protected with mattresses until they achieve full burial.

All loadings due to environmental conditions, including but not limited to, wave, current, soil subsidence etc. shall be accounted for in the stability design. The environmental loadings for design shall be, as a minimum, 100-year return period for operation condition. The environmental loadings shall be based on relevant metocean data and taken in the direction resulting in the worst loading combination on the mattresses. Soil properties and geotechnical data for design of mattress shall be based on relevant soil investigation data.

8.5 Design Requirements for Protection

Typically, concrete mattress shall be able to provide protection from dropped objects and trawl boards. Flexible concrete mattresses shall be capable of absorbing 15 kJ impact load and be stable under the relevant design environmental loads. Resistance to trawl boards can be achieved through the design of the mattress edges for example butt or tapered edge.

9.0 ROCK DUMPING DESIGN REQUIREMENTS

9.1 Rock Berm Requirements

The main purpose of the rock berm is to prevent damage caused by trawling and anchoring. To safeguard this protection, the berm should have enough thickness to withstand the external pressure and impact. The process of placing the rocks should be carefully planned to ensure the berm's stability and long-term effectiveness.

The method of rock installation should be suitable for the product to be deployed with the required profile and accuracy in the water depth at site. The impact of the falling rock onto the cable (or the cable protection system) should be confirmed to not compromise the cable integrity.

In the process of estimating the rock volume for the subsea cable protection, a cautious and conservative approach was adopted to define the rock grades. To ensure maximum stability and effectiveness, a two-layer rock berm is recommended, with smaller rock grades used as the infill material. The rock berm design shall be as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

The following Table 9-1 summarises the estimated mean rock size required for the rock berm inner fill cover and armour layer.

Berm Layer	Layer Cover Height (m)	Estimated mean rock size d50 (mm)
Inner Fill Layer	0.5m on seabed (covering power cable)	25mm – 150mm
Armour Layer	0.5m on top of Inner Fill Layer	150mm – 600mm

Table 9-1 Estimated Mean Rock Size for different water depths

All rock dumping requirements shall be in accordance as well as the provisions within [Ref.17] and [Ref.19]. The EPCI contractor shall verify the suitability of these estimated mean rock sizes for providing adequate protection and berm stability, during the detail engineering stage. The rock berm stability assessment shall aim to determine the minimum rock particle size that remains stable under specific berm configurations, design wave, and current conditions.

10.0 CROSSING PROTECTION REQUIREMENT

The power cable shall be fully protected along their whole length as per the Offshore Power Cable Protection Requirement Report [Ref.6]. The power cable shall be trenched and backfilled along their length. At crossing location where the cable burial requirements can't be achieved, it is necessary to protect against the potential hazards associated with dropped objects, shipping lanes and fishing activities that the power cable could be exposed to.

Damage to power cable from the above activities can be minimised by limiting the risks, if possible, or by preventing damage during the service life of the system with an appropriate protection philosophy. Most of the existing subsea architecture in waters off the Coast of the UK, including the Irish and North Seas, possesses a similar protection philosophy. Consequently, the protection measures adopted for the Liverpool Bay CCS power cables are consistent with general industry practice and are not based on the results of a field specific design study.

10.1 Dropped Object

The philosophy adopted, to mitigate the risk presented by dropped objects, is to minimise handling of objects over the power cables and, where necessary, provide protection and adopt strict handling procedures. Detailed protection philosophy is presented in [Ref.6].

Power cable approaching the Douglas CCS and all the satellite platforms (Hamilton North, Hamilton Main, Lennox) have been assessed for the risk of dropped objects landing on the cable. The general industry practice for dropped object protection philosophy normally consists of mattress protection for power cables resting on the seabed. A similar protection method shall be adopted for the cable crossing in the proximity of Douglas CCS platform.

10.2 Fishing Gear Interaction

The Irish Sea is an area of intense fishing activity, and that demersal fishing, i.e., otter trawls and trawl beams, is the predominant method used in these waters. The otter trawl consists of a wide net, held open by a pair of otter boards or doors, and towed along the seabed. Contact of the catching net with the seabed is maintained by a variety of chains and ground gear. The main threat this arrangement poses to cables is impact and entanglement with either of the otter boards.

In accordance with [Ref.6], fishing activity in the LBA study area is concentrated to the north west, and an area of actively fishing vessels is focussed between the LBA assets Hamilton, the Douglas Complex, Hamilton North and the buoy moored Oil Storage Installation (OSI). Additionally, there is an area of fishing activity to the south of the LBA study area, between Gwynt y Mor and Rhyl Flats wind farms.

The general industry practice for crossing protection against fishing gear interaction normally consists of mattress protection or rock berm for power cables resting on the seabed. A similar protection method shall be adapted for the cable crossing in the fishing activity zone. CONTRACTOR shall conform the adequacy of selected protection method once the following studies are completed and available:

- Fishing and Shipping Study Report
- Fishing and Maritime Traffic Report

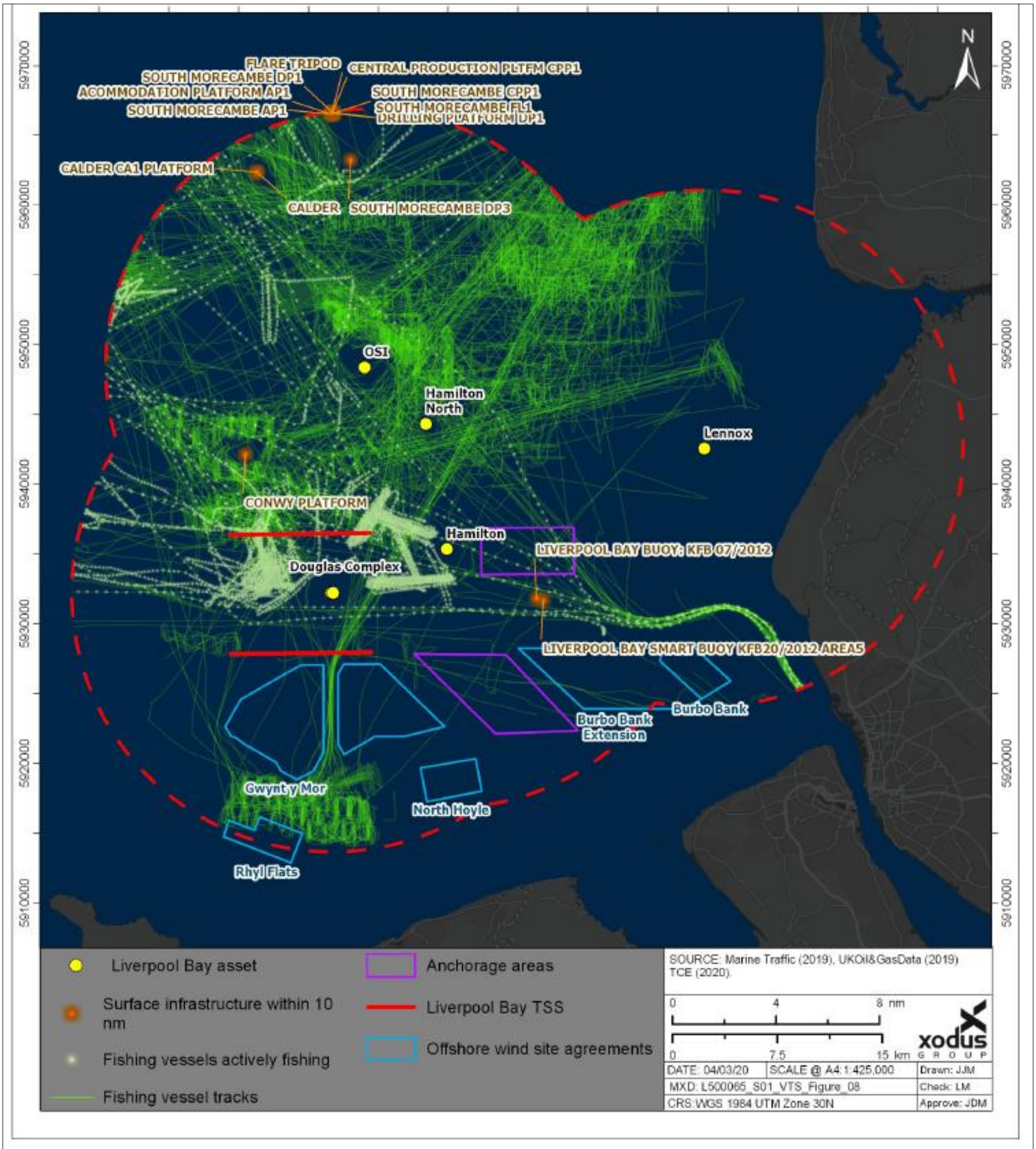

Figure 10-1 Fishing activity within LBA 10 nm Study Area [Ref.6]

10.3 Routine Vessel Traffic (Shipping Lane and In-Field Traffic)

In accordance with [Ref.6], vessel tracks from all routine and in-field vessels are identified within the 10 nm study area. The majority of routine vessel tracks (88.1%) within the whole Liverpool Bay Assets study area are associated with shipping lane traffic. Therefore, the cable crossings shall be protected with mattress or rock berm where the cable burial requirements can't be achieved. CONTRACTOR shall conform the adequacy of selected protection method once the following studies are completed and available:

- Anchoring Study Reports

- Fishing and Shipping Study Report
- Fishing and Maritime Traffic Report

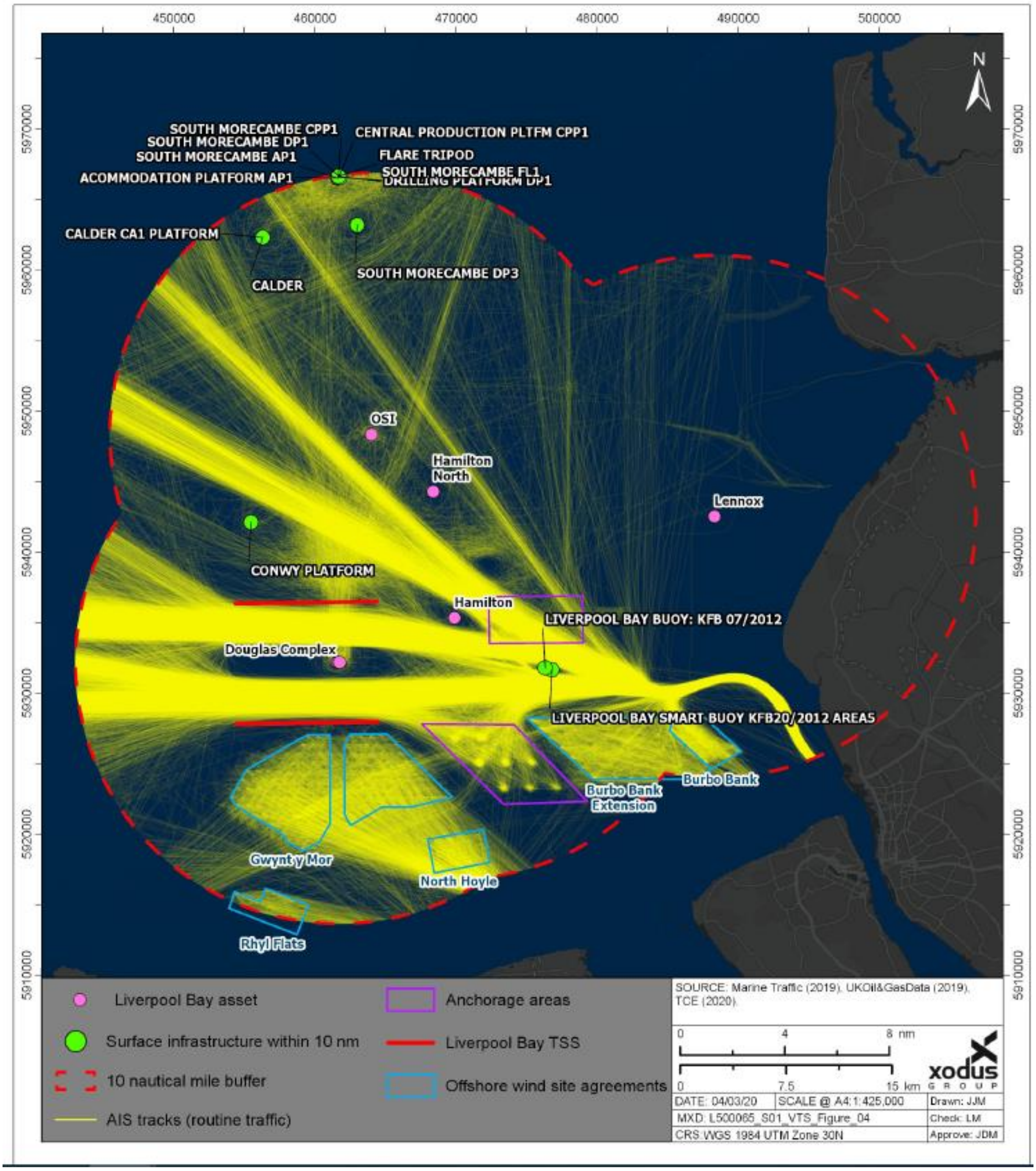

Figure 10-2 Routine Vessel tracks within LBA 10 nm Study Area [Ref.6]

11.0 CROSSING PROTECTION DESIGN

The following designs presented here is a base case protection solution of the power cables at the designated crossings.

11.1 Schematic of Burbo Bank Wind Farm Cable Crossing [PoAX-1]

Burbo Bank Extension Wind Farm is located in the Liverpool Bay approximately 7km north of Hoylake and Melos in the Wirral, 8.5km from Crosby beach and 12.2km from the Point of Ayr in Wales. The offshore substation will be situated inside the wind fam area and will be connected to the onshore cable through a 220kV submarine cables. The submarine cable route length is approximately 26km and has crossed the ENI's existing 20inch gas export pipeline (PL1030), 3inch condensate (PL1032) and 3inch methanol (PL1033) pipeline. A typical concrete mattress crossing design was adopted by Dong Energy (now Ørsted) for their cable crossing ENI's pipelines [Ref.22].

A similar concrete mattress crossing design is proposed for the new power cables (2 Nos.) from Point of Ayr to Douglas CCS platform crossing the Burbo Bank Extension submarine cable. The Burbo Bank Extension submarine cable is assumed to be buried at the crossing location to a depth of 1.65m. The crossing design consists of pre-lay concrete mattress on seabed and post-lay concrete mattress to ensure protection of new cables where the burial requirement of 2m is not achieved as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

11.1.1 Pre-lay Concrete Mattress Schematic

The following schematic is for reference purpose only. A pre-lay concrete mattress is placed on the seabed to achieve a minimum vertical separation of 0.3m between the crossed lines as show below in Figure 11-1. The power cable is the laid on top of the concrete mattress to cross the existing line.

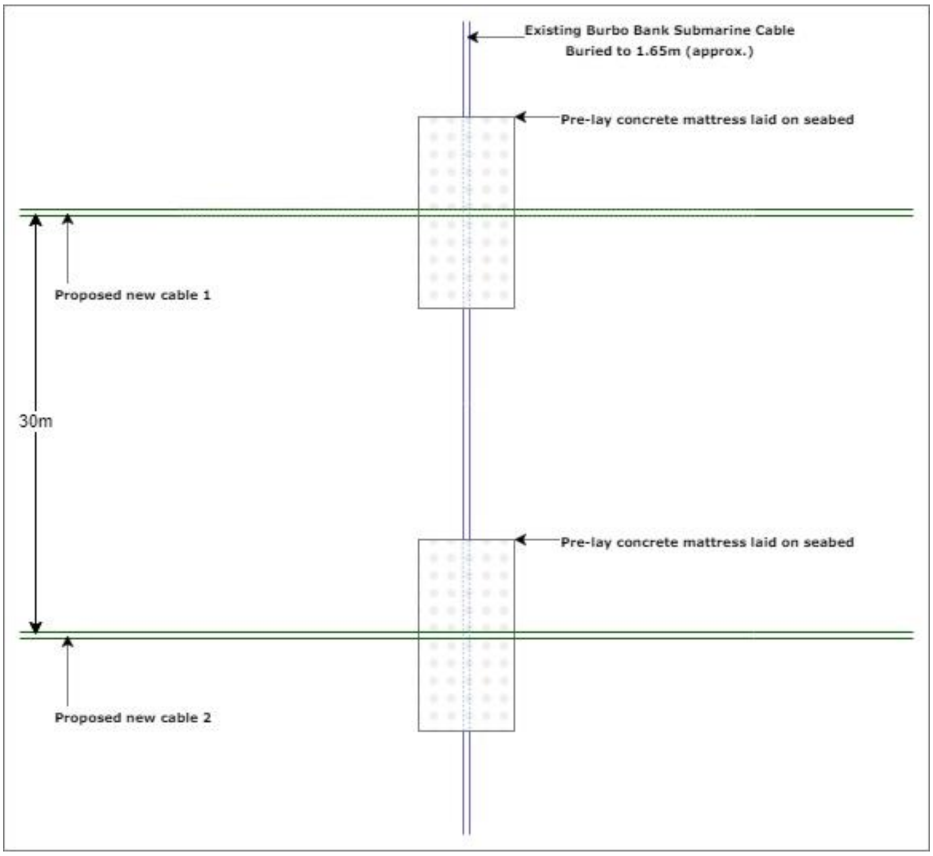

Figure 11-1 Pre-Lay Concrete Mattress Schematic for Burbo Wind Farm Extension Cable Crossing

11.1.2 Post-lay Protection Measure Schematic

The following schematic Figure 11-2 is for reference purpose only. The protection method is adopted based on the protection requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. Since the water depth is too shallow at 5m and shipping or fishing activities at the crossing location is unlikely as per Figure 10-1 and Figure 10-2, a concrete mattress protection method is adequate for the cable protection. The total length of protection and quantity of concrete mattress required are summarised in Table 5-2.

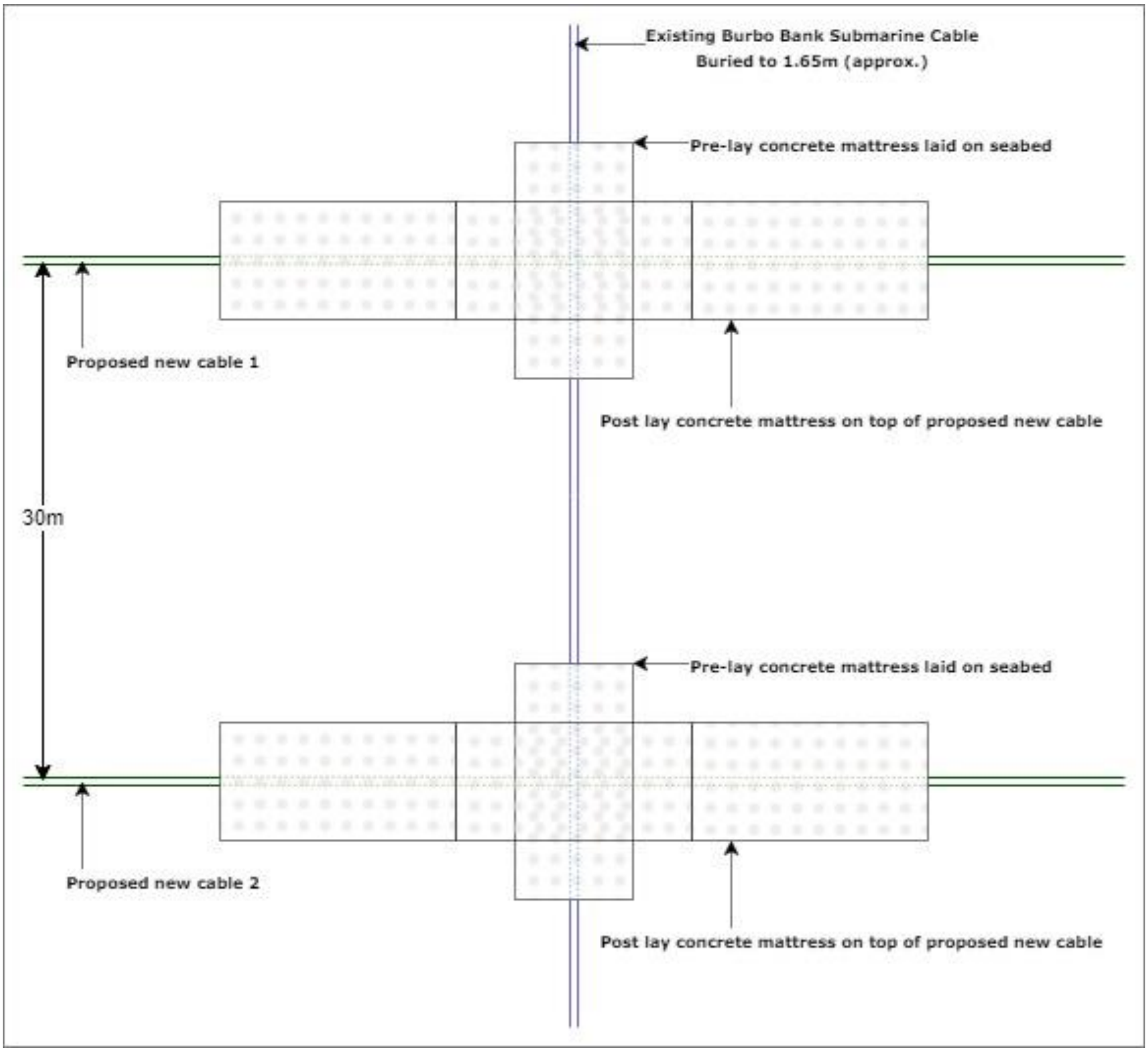

Figure 11-2 Final Crossing Design Schematic for Burbo Wind Farm Extension Cable Crossing

11.1.3 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. Calculations were performed for both the temporary installation case and permanent operation case. The results are presented below in Table 11-1.

Load Case	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation	1.428	2.019
Permanent – Operation	1.388	1.959

Table 11-1 Concrete Mattress Stability Results for the Burbo Bank Wind Farm Extension Cable Crossing

11.2 Schematic of North Hoyle Wind Farm (Export Cable) Crossing [PoAX-2 & PoAX-3]

North Hoyle is the UK's first major offshore wind farm. It comprises 30 wind turbine generators each capable of generating up to 2MW. The total installed capacity is therefore 60MW and enough electricity is generated each year for some 40,000 homes. The wind farm is situated 7–8 km off the North Wales coast where the water depth is 7–11m with a tidal range of 8m. Connection to the 132kV grid system is at Rhyl via two 33kV cables. The cable route has crossed the ENI's existing 20inch gas export pipeline (PL1030), 3inch condensate (PL1032) and 3inch methanol (PL1033) pipeline. A typical concrete mattress crossing design was adopted by developers (now owned by Greencoat UK Wind PLC) for their cables crossing ENI's pipelines [Ref.21].
A similar concrete mattress crossing design is proposed for the new cables (2 Nos.) crossing the two North Hoyle submarine cables. The North Hoyle submarine cable is assumed to be buried at the crossing location to a depth of 1.50m. The crossing design consists of pre-lay concrete mattress on seabed and post-lay concrete mattress to ensure protection of cable where the burial requirement of 2m is not achieved as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

11.2.1 Pre-lay Concrete Mattress Schematic

The following schematic is for reference purpose only. A pre-lay concrete mattress is placed on the seabed to achieve a minimum vertical separation of 0.3m between the crossed lines as show below in Figure 11-3. The power cable is the laid on top of the concrete mattress to cross the existing line.

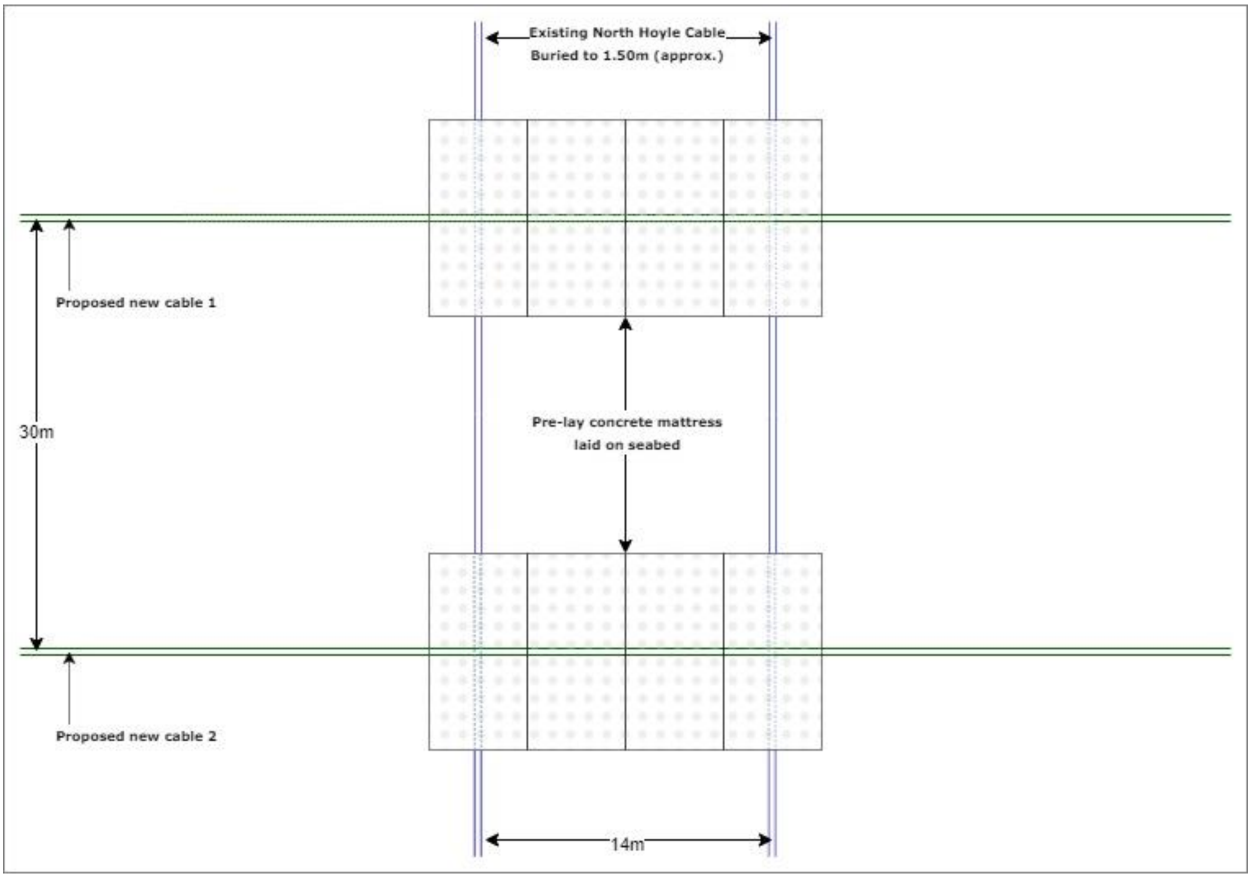

Figure 11-3 Pre-Lay Concrete Mattress Schematic for North Hoyle Cable Crossing

11.2.2 Post-lay Protection Measure Schematic

The following schematic Figure 11-4 is for reference purpose only. The protection method is adopted based on the protection requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. Since the water depth is too shallow at 7m and shipping or fishing activities at the crossing location is unlikely as per Figure 10-1 and Figure 10-2, a concrete mattress protection method is adequate for the cable protection. The total length of protection and quantity of concrete mattress required are summarised in Table 5-3.

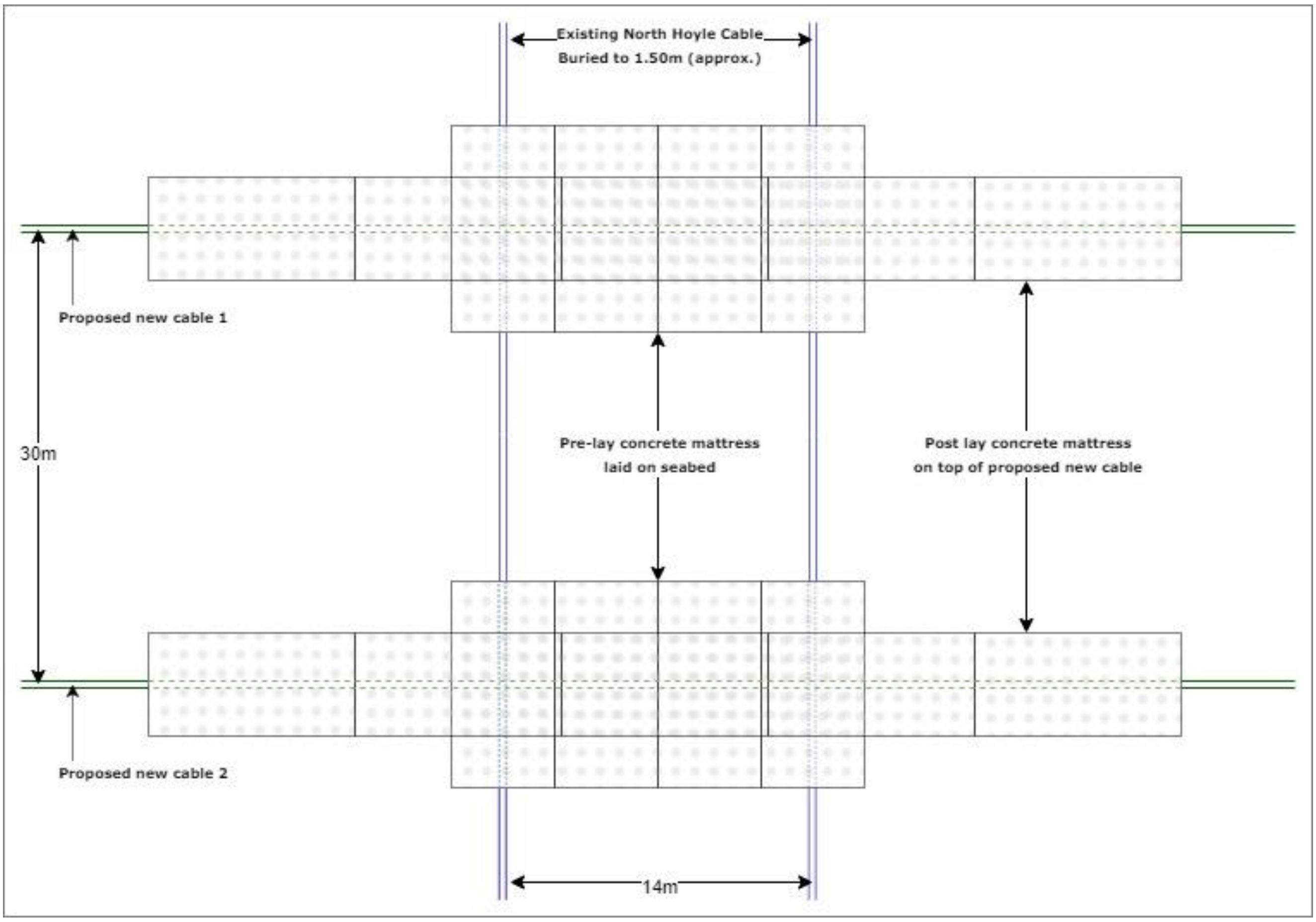

Figure 11-4 Final Crossing Design Schematic for North Hoyle Cable Crossing

11.2.3 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. Calculations were performed for both the temporary installation case and permanent operation case. The results are presented below in Table 11-2.

Load Case	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation	1.646	2.324
Permanent – Operation	1.596	2.252

Table 11-2 Concrete Mattress Stability Results for the North Hoyle Export Cables Crossing

11.3 Schematic of Gwynt y Môr Wind Farm (Export Cable) Crossing [PoAX-4 & PoAX-5]

Gwynt y Môr is an offshore Wind Farm located 13km offshore of the North Wales coast, between Prestatyn and Colwyn Bay, within proximity of the North Hoyle and EirGrid Wind Farms. The offshore substation will be situated inside the wind fam area and will be connected to the onshore cable through a 132kV submarine cables. There are two submarine cables separated by 50m crossed the ENI's existing 20inch gas export pipeline (PL1030), 3inch condensate (PL1032) and 3inch methanol (PL1033) pipeline [Ref.21]. A typical concrete mattress with rock berm (coverage of 0.5m) crossing design was adopted by developers (owned by Gwynt y Môr OFTO) for their cables crossing ENI's pipelines.

A similar crossing design is proposed for the new cables (2 Nos.) crossing the two Gwynt y Môr submarine cables. The Gwynt y Môr submarine cable is assumed to be buried at the crossing location to a depth of 1.65m. The crossing design consists of pre-lay concrete mattress on seabed and post-lay rock berm to ensure protection of cable where the burial requirement of 2m is not achieved as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

11.3.1 Pre-lay Concrete Mattress Schematic

The following schematic is for reference purpose only. A pre-lay concrete mattress is placed on the seabed to achieve a minimum vertical separation of 0.3m between the crossed lines as show below in Figure 11-5. The power cable is the laid on top of the concrete mattress to cross the existing line.

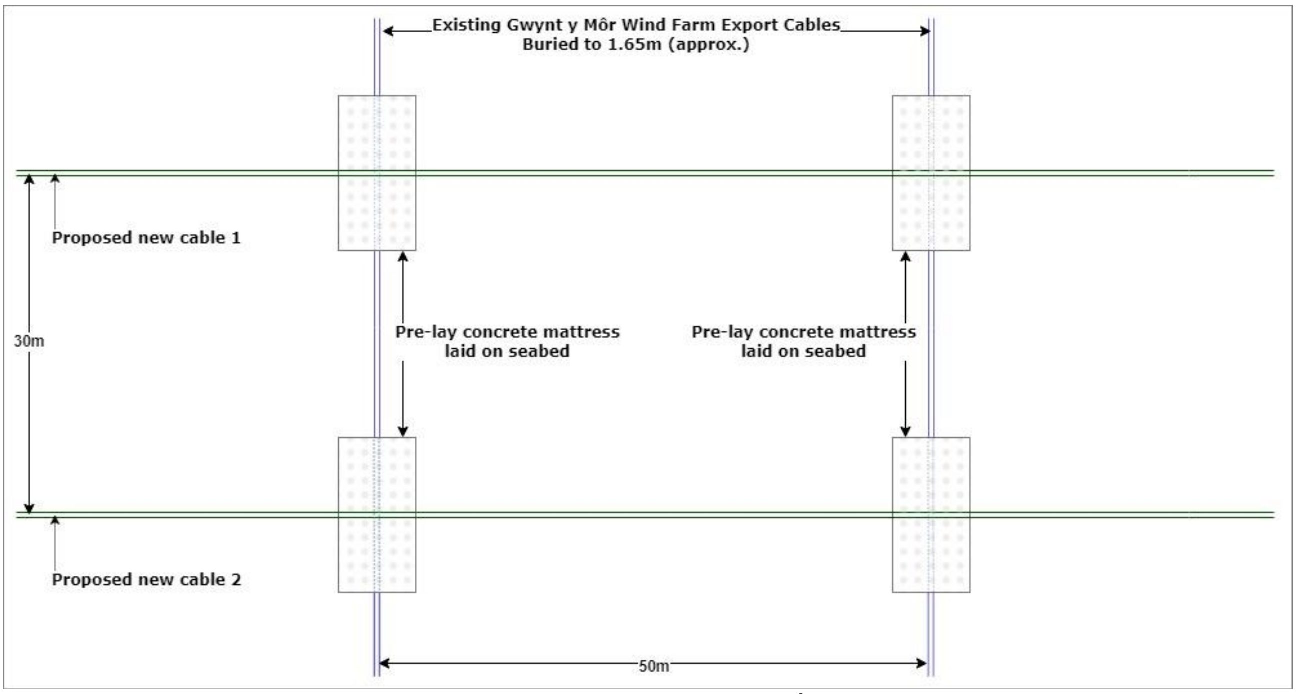

Figure 11-5 Pre-Lay Concrete Mattress Schematic for Gwynt y Môr Wind Farm (Export Cable) Crossing

11.3.2 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. The results are presented below in Table 11-3.

Load Case	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation	<1.1 Note 1	1.324
Note 1: Stability assessment against leading edge lift shall be confirmed during detailed design engineering by the CONTRACTOR using accurate metocean data for water depths of 12m.		

Table 11-3 Concrete Mattress Stability Results for the Gwynt y Môr Wind Farm (Export Cable) Crossing

11.3.3 Post-lay Protection Measure Schematic

The following schematic Figure 11-6 is for reference purpose only. The protection method is adopted based on the protection requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. In accordance with Figure 10-1 and Figure 10-2 the crossing location experiences fishing and routine vessel traffic and therefore crossings shall be protected with post laid rock dumping. The total length of protection and volume of rock required for the rock berm are summarised in Table 5-3.

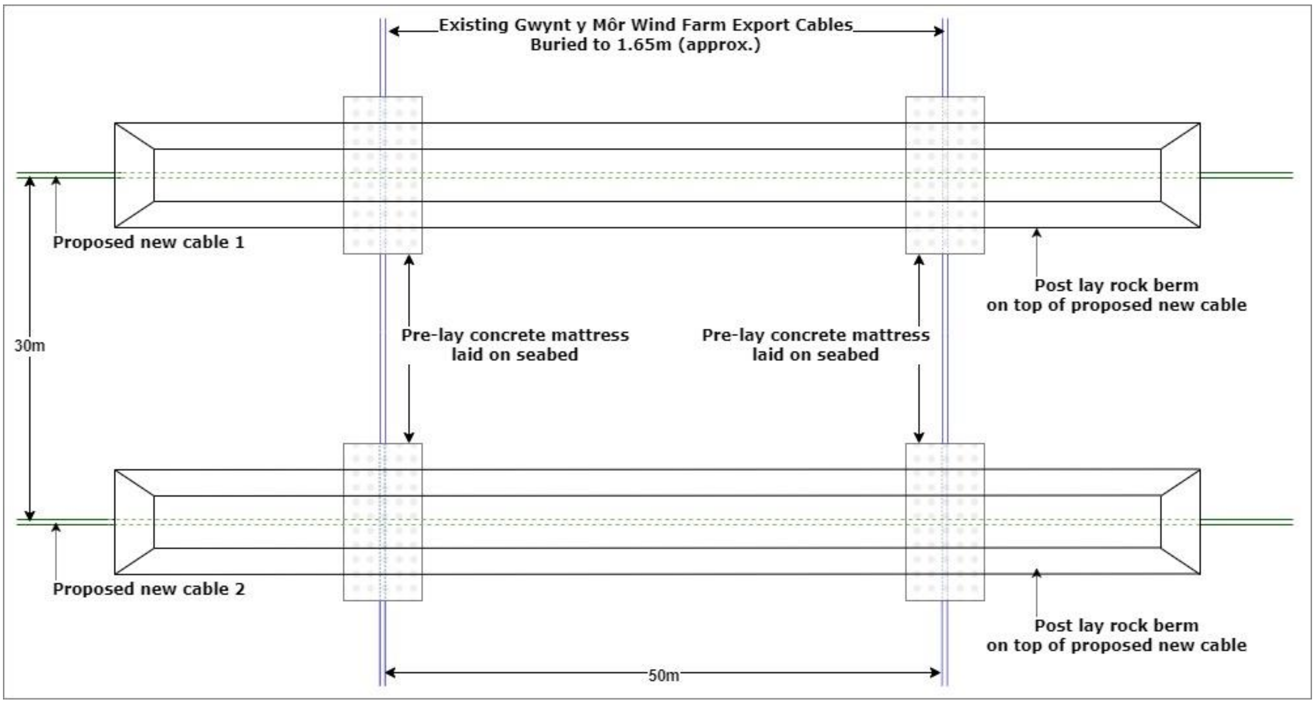

Figure 11-6 Final Crossing Design Schematic for Gwynt y Môr Wind Farm (Export Cable) Crossing

11.4 Schematic of Gwynt y Môr Wind Farm (Inter Array Cable) Crossing [PoAX-6]

The inter-field submarine cable has crossed the ENI's existing 20inch gas export pipeline (PL1030), 3inch condensate (PL1032) and 3inch methanol (PL1033) pipeline [Ref.21]. A typical concrete mattress with rock berm (coverage of 0.5m) crossing design was adopted by developers (owned by Gwynt y Môr OFTO) for their cable crossing ENI's pipelines.

A similar crossing design is proposed for the new cables (2 Nos.) crossing the two Gwynt y Môr submarine cables. The Gwynt y Môr submarine cable is assumed to be buried at the crossing location to a depth of 1.65m. The crossing design consists of pre-lay concrete mattress on seabed and post-lay rock berm to ensure protection of cable where the burial requirement of 2m is not achieved as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

11.4.1 Pre-lay Concrete Mattress Schematic

The following schematic are for reference purpose only. A pre-lay concrete mattress is placed on the seabed to achieve a minimum vertical separation of 0.3m between the crossed lines as show below in Figure 11-7. The power cable is the laid on top of the concrete mattress to cross the existing line.

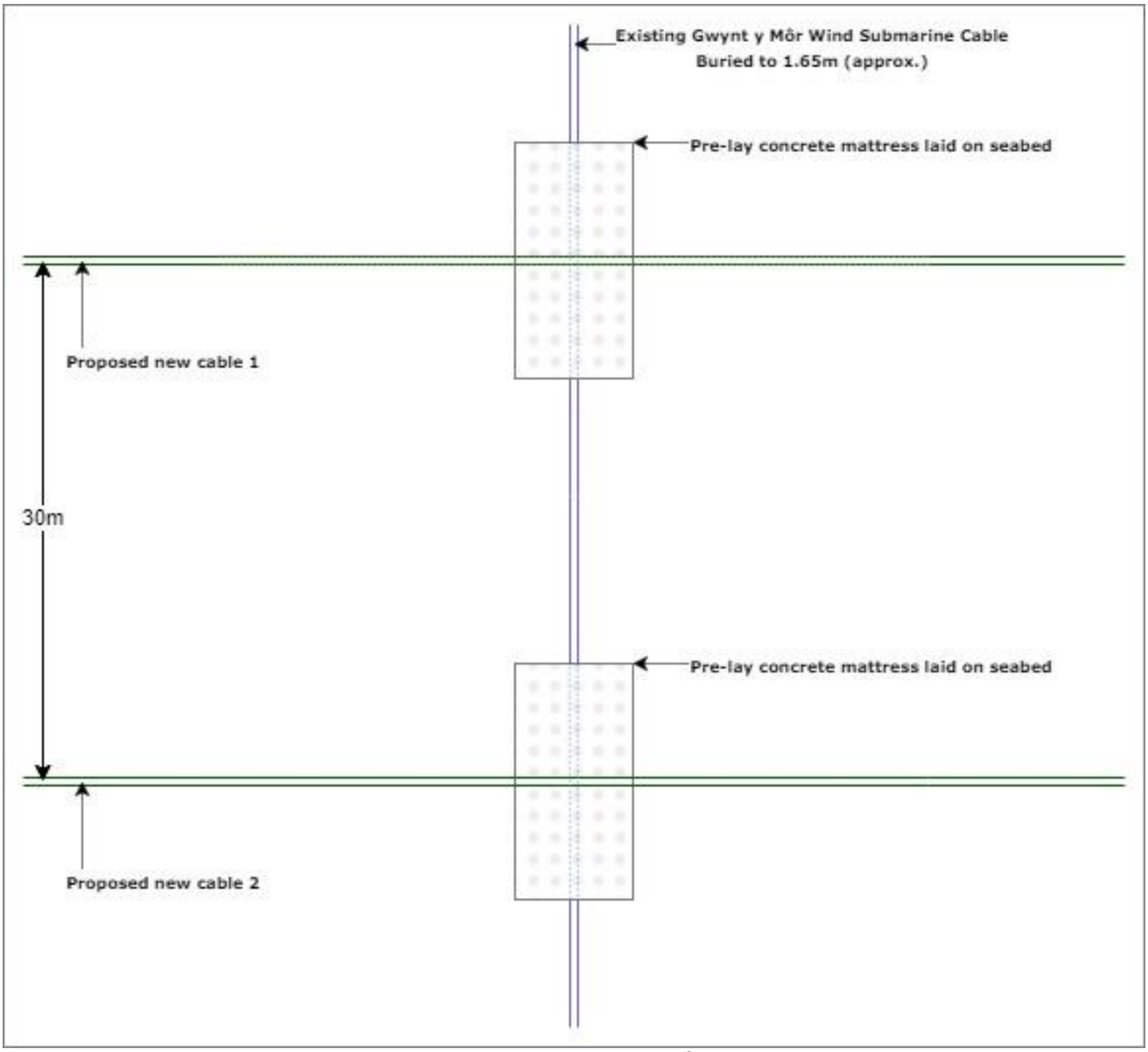

Figure 11-7 Pre-Lay Concrete Mattress Schematic for Gwynt y Môr Wind Farm (Inter field Cable) Crossing

11.4.2 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. The results are presented below in Table 11-4.

Load Case	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation	1.329	1.982

Table 11-4 Concrete Mattress Stability Results for the Gwynt y Môr Wind Farm (Inter Array Cable) Crossing

11.4.3 Post-lay Protection Measure Schematic

The following schematic is for reference purpose only. The protection method is adopted based on the protection requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. In accordance with Figure 10-1 and Figure 10-2 the crossing location experiences fishing and routine vessel traffic and therefore crossings shall be protected with post laid rock dumping. The total length of protection and volume of rock required for the rock berm are summarised in Table 5-2.

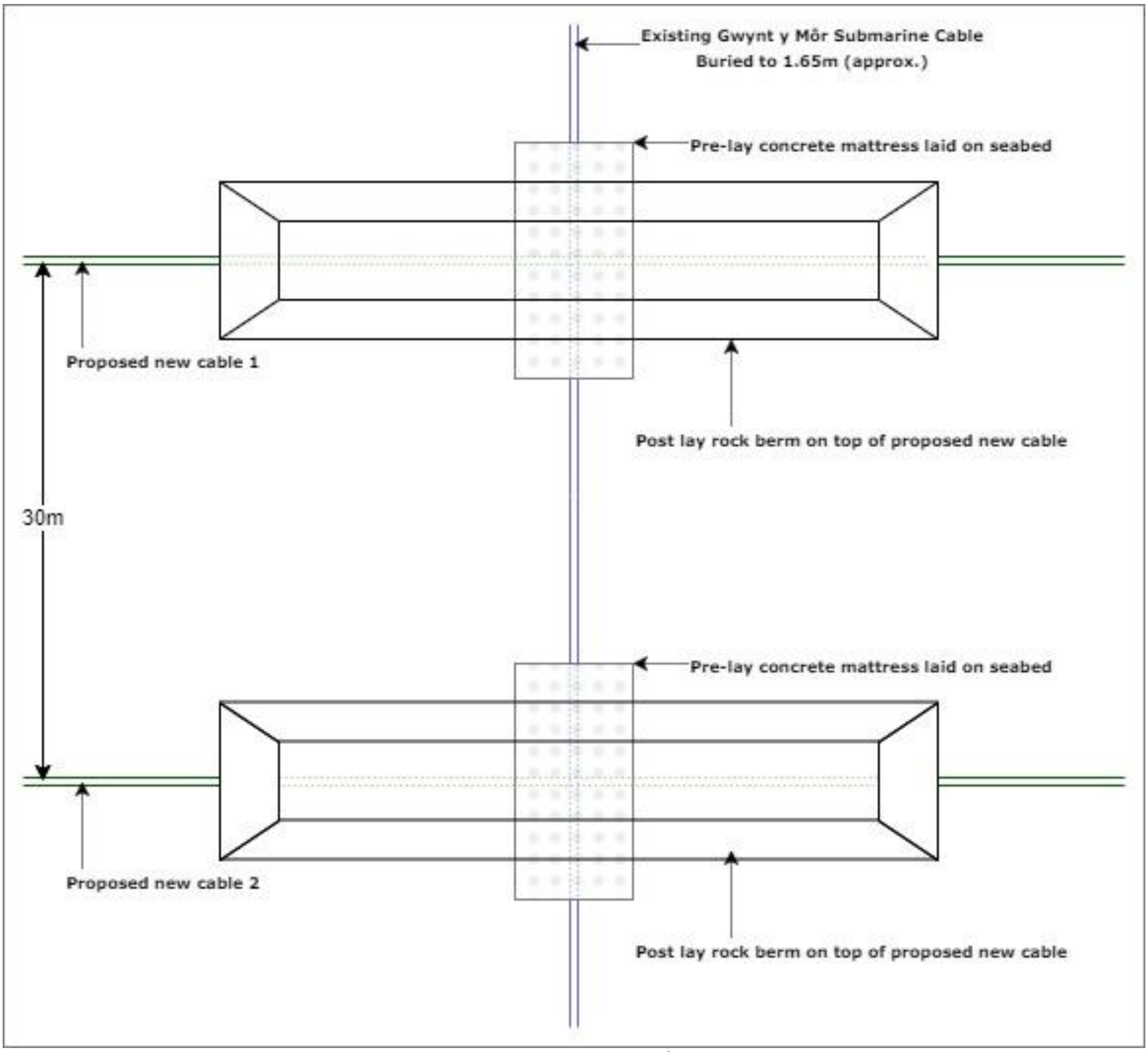

Figure 11-8 Final Crossing Design Schematic for Gwynt y Môr Wind Farm (Inter field Cable) Crossing

11.5 Schematic of Western Link HVDC Cable Crossing [PoAX-7 & PoAX-8]

The Western HVDC Link is a high-voltage direct current (HVDC) undersea electrical link in the United Kingdom, between Hunterston in Western Scotland and Flintshire Bridge (Connah's Quay) in North Wales, routed to the west of the Isle of Man. There are two submarine cables separated by 30m crossed the ENI's existing 20inch gas export pipeline (PL1030), 3inch condensate (PL1032) and 3inch methanol (PL1033) pipeline. A typical concrete mattress with rock berm (coverage of 0.8m) crossing design was adopted by developers Scottish Power Transmission and National Grid for their cables crossing ENI's pipelines.

A similar crossing design is proposed for the new cables (2 Nos.) crossing the two Western Link HVDC submarine cables. The Western Link HVDC submarine cable is assumed to be buried at the crossing location to a depth of 2.0m. The crossing design consists of pre-lay concrete mattress on seabed and post-lay rock berm to ensure protection of cable where the burial requirement of 2m is not achieved as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

11.5.1 Pre-lay Concrete Mattress Schematic

The following schematic are for reference purpose only. A pre-lay concrete mattress is placed on the seabed to achieve a minimum vertical separation of 0.3m between the crossed lines as show below in Figure 11-9. The power cable is the laid on top of the concrete mattress to cross the existing line.

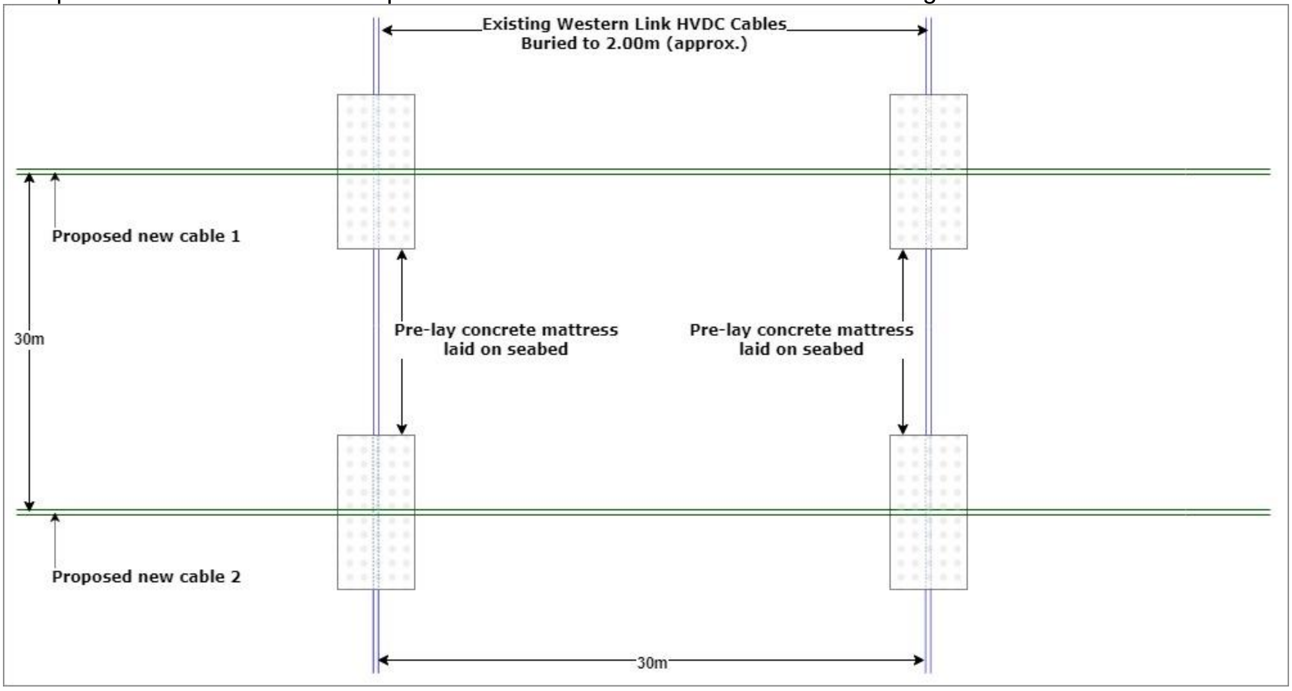

Figure 11-9 Pre-Lay Concrete Mattress Schematic for Western Link HVDC Cable Crossing

11.5.2 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. The results are presented below in Table 11-5.

Load Case	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation	2.233	3.308

Table 11-5 Concrete Mattress Stability Results for the Western Link HVDC Cable Crossing

11.5.3 Post-lay Protection Measure Schematic

The following schematic is for reference purpose only. The protection method is adopted based on the protection requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. In accordance with Figure 10-1 and Figure 10-2 the crossing location experiences fishing and significant routine vessel traffic and therefore crossings shall be protected with post laid rock dumping. The total length of protection and volume of rock required for the rock berm are summarised in Table 5-3.

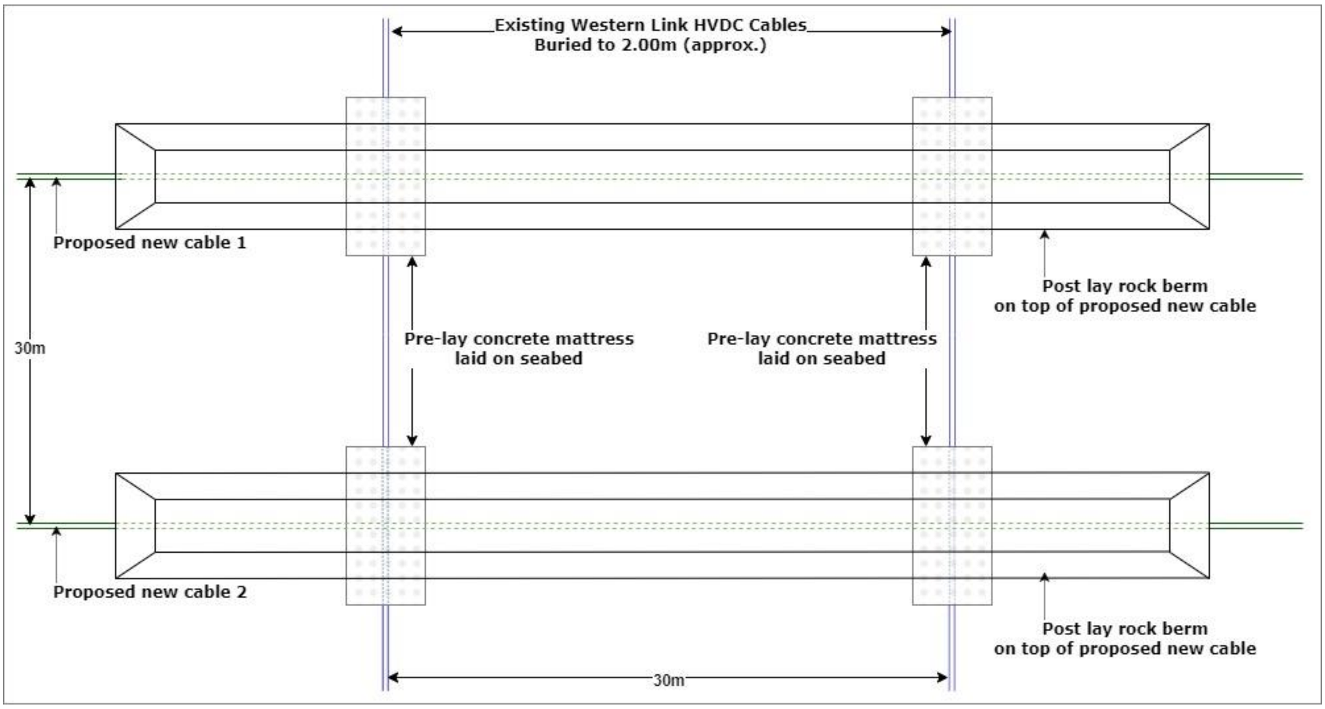

Figure 11-10 **Final Crossing Design Schematic for Western Link HVDC Cable Crossing**

11.6 Schematic of Typical Power Cable Crossing Buried Pipeline (Single Crossing)

In section 6.2 of the report, the following cable crossings are identified as single crossing.

- Crossing DHNX-4 of Power Cable from Douglas CCS to Hamilton North
- Crossing DLX-4 of Power Cable from Douglas CCS to Lennox

The power cables to Hamilton North and Lennox are crossing the existing 14" Oil Export (PL 1031) to OLU pipeline with a crossing angle of 68^{o} and 67^{o} respectively. The existing pipeline is buried to a depth of 0.8m, and the power cable crossing design requires a minimum vertical separation of 0.3m above it. To ensure this, pre-lay concrete mattresses will be placed on the seabed above the existing pipeline.

The crossing is situated in a zone characterised by a busy shipping lane and the presence of fishing vessels. Due to these factors, the Offshore Power Cable Protection Requirement [Ref.6] study highlights the necessity of ensuring adequate protection for the crossing to mitigate potential risks associated with shipping and fishing activities. As a result, a rock berm post-lay protection measure has been adopted to protect the power cables as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

Figure 11-11 provides the schematic (for reference only) of typical crossing design with post lay concrete mattress or rock berm as protection measure. The total length of protection and the quantity of concrete mattress / volume of rock required for the rock berm are summarised in Table 5-2.

11.6.1 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. Calculations were performed for both the temporary installation case and permanent operation case. The results are presented below in Table 11-6.

Load Case	Water Depth (m)	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation (Douglas CCS Platform Proximity)	30	2.208	3.271
	25	1.752	2.615
Permanent – Operation (Douglas CCS Platform Proximity)	30	1.490	2.210
	25	1.189	1.777

Table 11-6 Concrete Mattress Stability Results for Single Crossing Near to Douglas CCS Platform

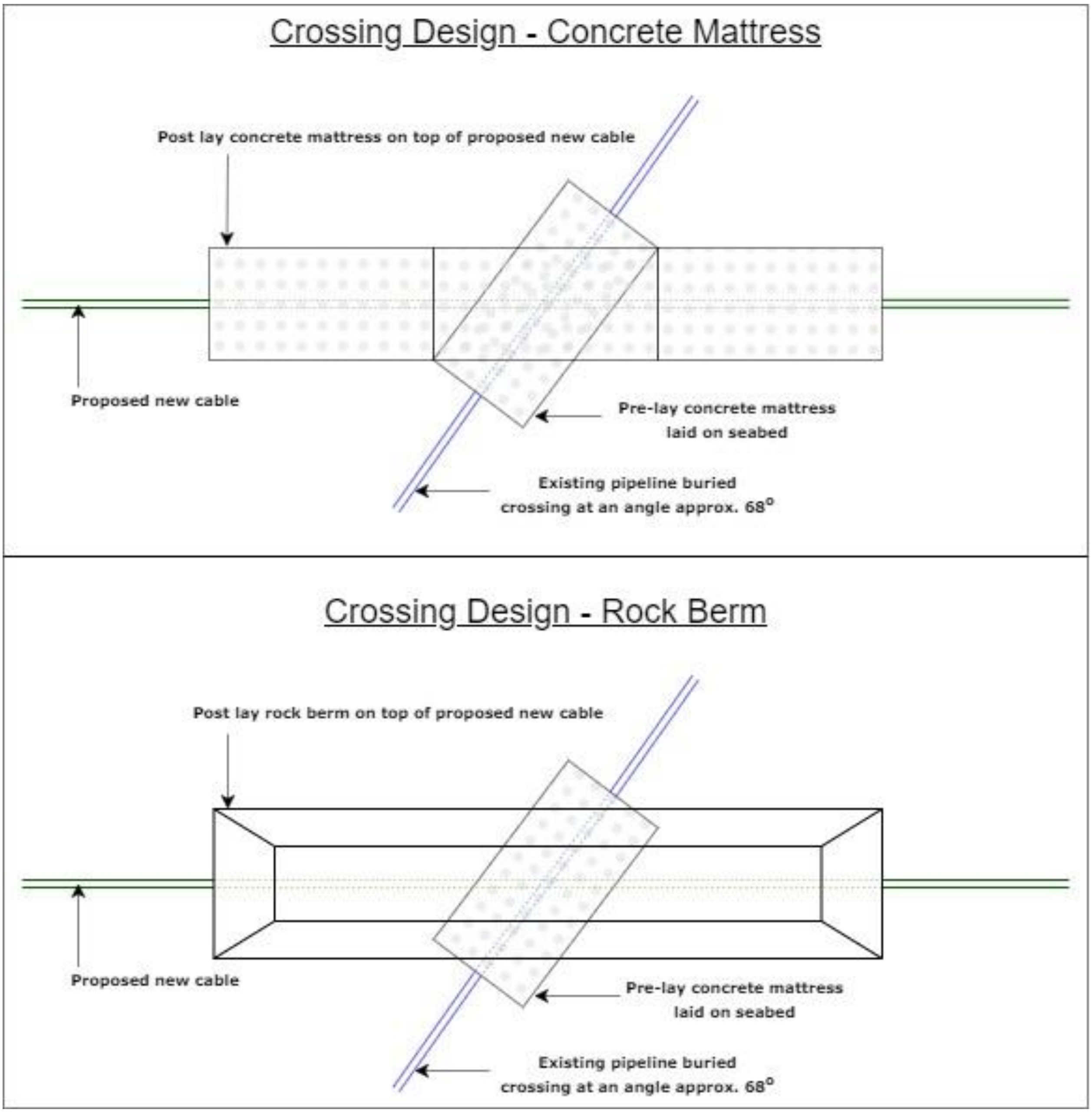

Figure 11-11 Typical Power Cable Crossing Buried Pipeline / Cable (Single Crossing)

11.7 Schematic of Typical Power Cable Crossing Buried Pipeline / Cable (Multiple Crossing)

In section 6.2 of the report, the following cable crossings are identified as multiple crossing.

- Crossing PoAX-9 & PoAX-10 of Power Cables (1 & 2) from Point of Ayr to Douglas CCS
- Crossing DHNX-1, DHNX-2 & DHNX-3 of Power Cable from Douglas CCS to Hamilton North
- Crossing DHNX-5, & DHNX-6 of Power Cable from Douglas CCS to Hamilton North
- Crossing DLX-1, DLX-2 & DLX-3 of Power Cable from Douglas CCS to Lennox
- Crossing DLX-5, & DLX-6 of Power Cable from Douglas CCS to Lennox

The existing pipelines and cables are buried to a depth of 0.8m. The power cable crossing design involves placing a pre-lay concrete mattress on the seabed to achieve a minimum vertical separation of 0.3m between the power cable and the existing line.

Post-lay concrete mattresses will be placed on top of the cable to protect it in areas where the burial requirement of 2m is not achieved, as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6]. Moreover, in areas characterised by busy shipping lanes and the presence of fishing vessels, an alternative protection method of rock berm protection is adopted as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

Table 11-7 summarises the recommended crossing design solution for all the crossings listed above. The total length of protection and the quantity of concrete mattress / volume of rock required for the rock berm are summarised in Table 5-3.

Sl No.	Crossing ID	Proposed Crossing Design	
		Pre-Lay	Post-Lay Protection
1	PoAX-9 & PoAX-10	Concrete Mattress	Concrete Mattress
2	DHNX-1, DHNX-2 & DHNX-3	Concrete Mattress	Rock Berm
3	DHNX-5, & DHNX-6	Concrete Mattress	Rock Berm
4	DLX-1, DLX-2 & DLX-3	Concrete Mattress	Rock Berm
5	DLX-5, & DLX-6	Concrete Mattress	Rock Berm

Table 11-7 Proposed Crossing Design Requirements (Multiple Crossing)

Figure 11-12 provides the schematic (for reference only) of typical crossing design (multiple crossings) with post lay concrete mattress and rock berm.

11.7.1 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. Calculations were performed for both the temporary installation case and permanent operation case. The results are presented below in Table 11-8.

Load Case	Water Depth (m)	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation (Douglas CCS Platform Proximity)	30	2.208	3.271
	25	1.752	2.615
Permanent – Operation (Douglas CCS Platform Proximity)	30	1.490	2.210
	25	1.189	1.777

Table 11-8 Concrete Mattress Stability Results for Crossings Near to Douglas CCS Platform

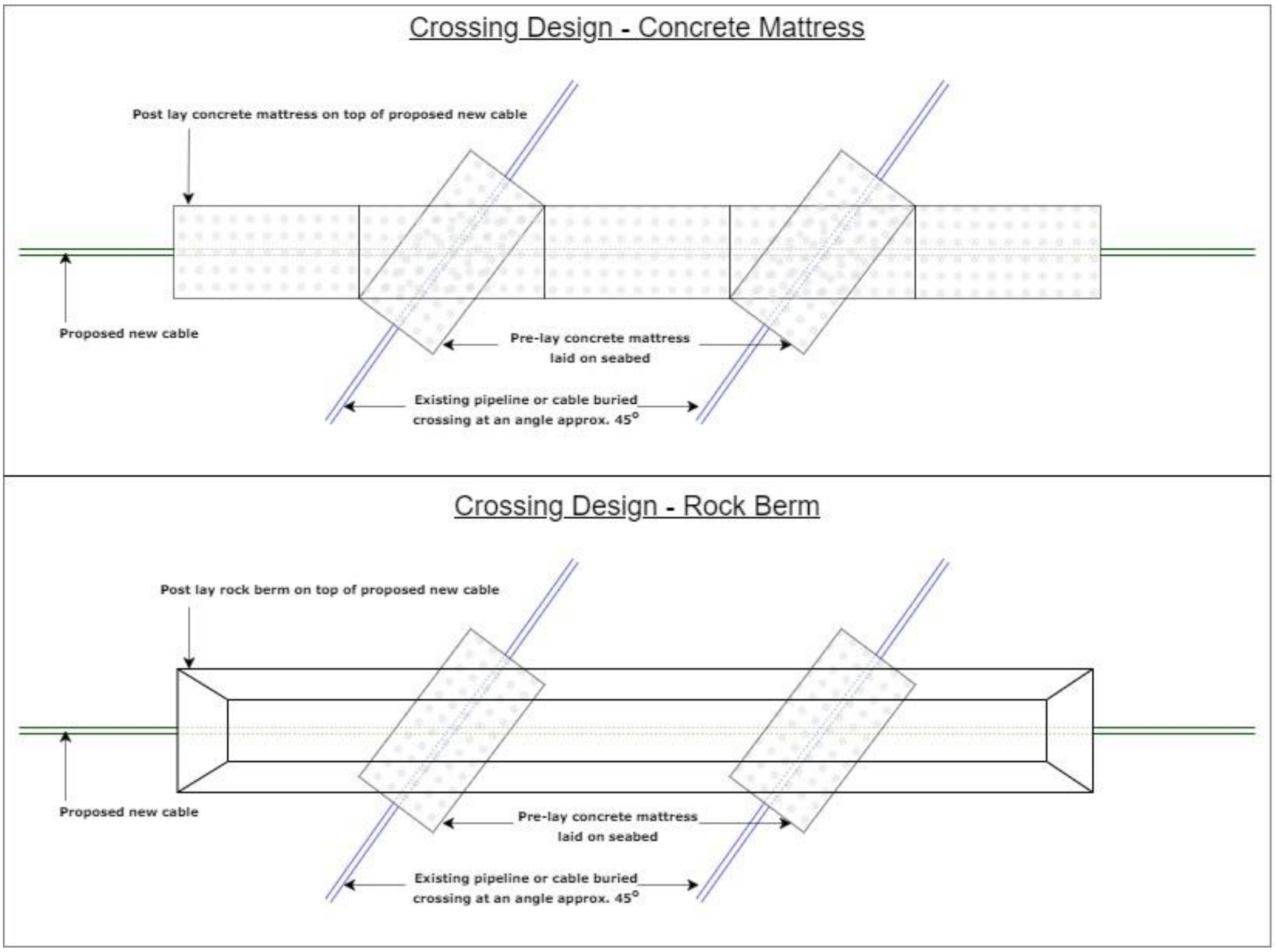

Figure 11-12 Typical Power Cable Crossing Buried Pipeline / Cable (Multiple Crossing)

11.8 Schematic of Power Cable Crossing for Douglas CCS to Hamilton Main (Douglas CCS Platform Approach)

The power cable from Douglas CCS to Hamilton Main features crossings solely located at the Douglas CCS platform approach, with no further crossings along the remaining cable route. A concrete mattress based design is proposed for crossings DHMX-2 to DHMX-5. The power cable crossing design involves placing a pre-lay concrete mattress on the seabed to achieve a minimum vertical separation of 0.3m between the cable and the existing line. Additionally, as a post-lay protection measure, concrete mattresses will be laid on top of the new power cable until it reaches a burial depth of 2m, as per the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

In the case of DHMX-1 crossing, the power cable is crossing with the existing 14" PL 1031 Oil Export Pipeline to OSI which is considered for future decommissioning and removal. To facilitate the future decommissioning activities, a pre-lay concrete bridge support based crossing method as stated in Section 7.1.3 is adopted for the crossing. This approach is particularly advantageous for future scenarios when the line beneath the bridge may need to be accessed for decommissioning and removal. The crossing design is achieved by placing a concrete bridge support on seabed on top of the existing asset. The power cable is laid on top of the bridge structure to cross the existing line and also achieving a minimum vertical separation of 0.3m. To ensure post-lay protection, the cable is then covered with concrete mattresses in accordance with the requirements specified in the Offshore Power Cable Protection Requirement [Ref.6].

Figure 11-13 provides the schematic of crossing design (multiple crossings) with post lay concrete mattress at Douglas CCS Platform approach. The total length of protection and quantity of concrete mattress required are summarised in Table 5-4.

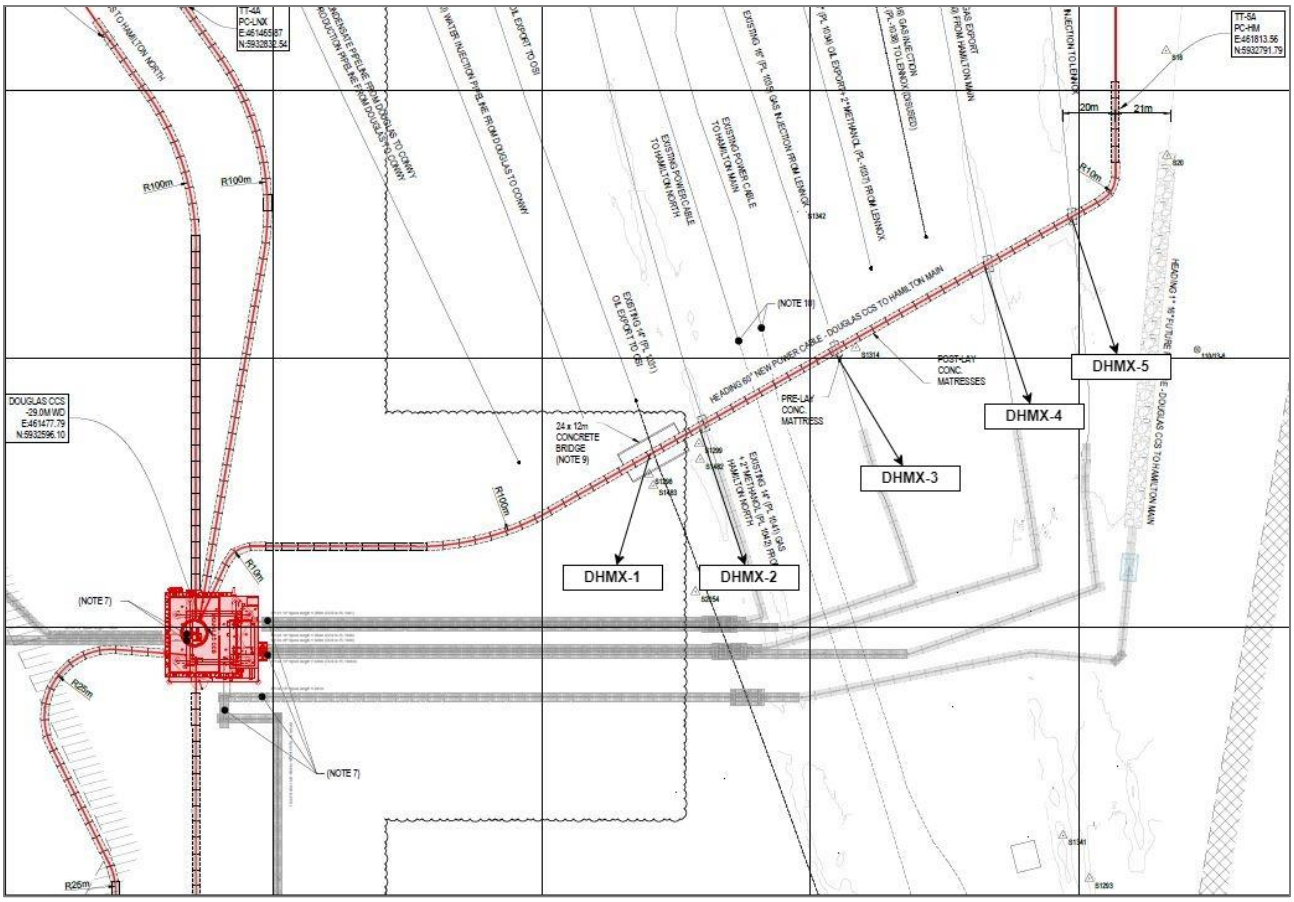

Figure 11-13 Power Cable Crossings at Douglas CCS Platform Approach

11.8.1 Concrete Mattress Stability Check

A concrete mattress stability calculation was performed based on the data presented in [Ref.1], [Ref.5] and methodology presented in 8.3. Calculations were performed for both the temporary installation case and permanent operation case. The results are presented below in Table 11-8.

Load Case	Water Depth (m)	Mattress dislodgment Edge Lift S.F.	Mattress dislodgment Sliding S.F.
Temporary – Installation (Douglas CCS Platform Proximity)	30	2.208	3.271
	25	1.752	2.615
Permanent – Operation (Douglas CCS Platform Proximity)	30	1.490	2.210
	25	1.189	1.777

Table 11-9 Concrete Mattress Stability Results for Crossings at Douglas CCS Platform Approach