Scottish Hydro Electric Power Distribution plc

Mossbank - Yell Emergency Cable Replacement

Project Description

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REVISIONS & APPROVALS

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ABBREVIATIONS

ABBREVIATION	DEFINITION
3D	Three-Dimensional
CBA	Cost Benefit Analysis
CEMP	Construction Environmental Management Plan
CLV	Cable Lay Vessel
DP	Dynamic Positioning
DSV	Dive Support Vessel
EPS	European Protected Species
FLMAP	Fisheries Liaison Mitigation Action Plan
FO	Fibre Optic
HDD	Horizontal Directional Drill
HDPE	High Density Polyethylene
HLNRA	High Level Navigational Risk Assessment
HVAC	High Voltage Alternating Current
Kg	Kilograms
kg/m	Kilograms per Metre
km	Kilometre
kV	Kilovolt
LAT	Lowest Astronomical Tide
m	Metre
MBES	Multibeam Echosounder
MCA	Marine and Coastguard Agency
MEA	Marine Environmental Appraisal
MHWS	Mean High Water Springs
MLA	Marine Licence Application
MLWS	Mean Low Water Springs
mm / mm^2	Millimetres / Millimetres Squared
OCT	Open-Cut Trench
OHL	Overhead Line
OIMD	Operation, Inspection, Maintenance and Decommissioning
OoS	Out of Service
PLGR	Pre-Lay Grapnel Run
PPY	Polypropylene

ABBREVIATION	DEFINITION
ROV	Remotely Operated Vehicle
SHEPD	Scottish Hydro Electric Power Distribution plc
TJP	Transition Joint Pit
t	Tonne
UK	United Kingdom
USBL	Ultra Short Baseline
UXO	Unexploded Ordnance
VMP	Vessel Management Plan
XLPE	Cross-linked polyethylene

1 INTRODUCTION

1.1 Overview

Scottish Hydro Electric Power Distribution plc (SHEPD) holds a licence under the Electricity Act 1989 for the distribution of electricity in the north of Scotland including the Islands. It has a statutory duty to provide an economic and efficient system for the distribution of electricity and to ensure that its assets are maintained to provide a safe, secure and reliable supply to customers.

In May 2024, SHEPD identified that one of the subsea cables connecting Mainland Shetland (Mossbank) to Yell had faulted. The cable was installed in 2009 (Mossbank – Yell North 1), as shown in Figure 1-1. In this location there is also a currently active subsea cable that was replaced in 2019 (Mossbank – Yell South 2). An options evaluation process recommended complete replacement of the 2009 faulted cable.

The proposed cable replacement ('the Project') will involve the installation of a new 33 kilovolt (kV) subsea cable and associated cable stabilisation and protection, together with the removal of the intertidal sections of the existing faulted and Out of Service (OoS) cables, where required. Installation of this cable is required to replace the existing faulted cable and restore connection to the power distribution network providing supply to the communities on Yell, Unst and Fetlar. The cable installation is currently planned to be undertaken during summer 2025, i.e., ahead of winter and anticipated deterioration in weather conditions.

The proposed replacement cable will have an approximate length of 4 kilometres (km) and it will be constructed between the landfalls at Mossbank (Mainland Shetland) and Hoga (Yell) to tie into existing distribution networks (Figure 1-2). The final cable route has not yet been determined. As such, to provide flexibility for final route engineering, this Project Description considers a 1.7 km^2 proposed cable installation corridor, within which the Mossbank to Yell replacement cable will be located. The final route selection will be based on further detailed route engineering and design parameters, while taking environmental and other constraints into account.

This Project Description is designed to provide a consolidated point of reference for all proposed activities. The Project Description should be read in conjunction with the following documents:

- Marine Environmental Appraisal (MEA);
- Marine Licence Application (MLA) Form;
- European Protected Species (EPS) Licence Application Form;
- Works Licence Application Form under Zetland County Council Act 1974;
- Marine Construction Environmental Management Plan (CEMP);
- High Level Navigational Risk Assessment (HLNRA);
- Shetland Regional Fisheries Liaison Mitigation Action Plan (FLMAP);
- How SHEPD Co-Exists with Other Marine Users;Operation, Inspection, Maintenance and Decommissioning Strategy (OIMD); and
- Mossbank-Yell Cost Benefit Analysis (CBA) Summary Report.

Figure 1-1 Existing subsea cable locations and fault and damage locations

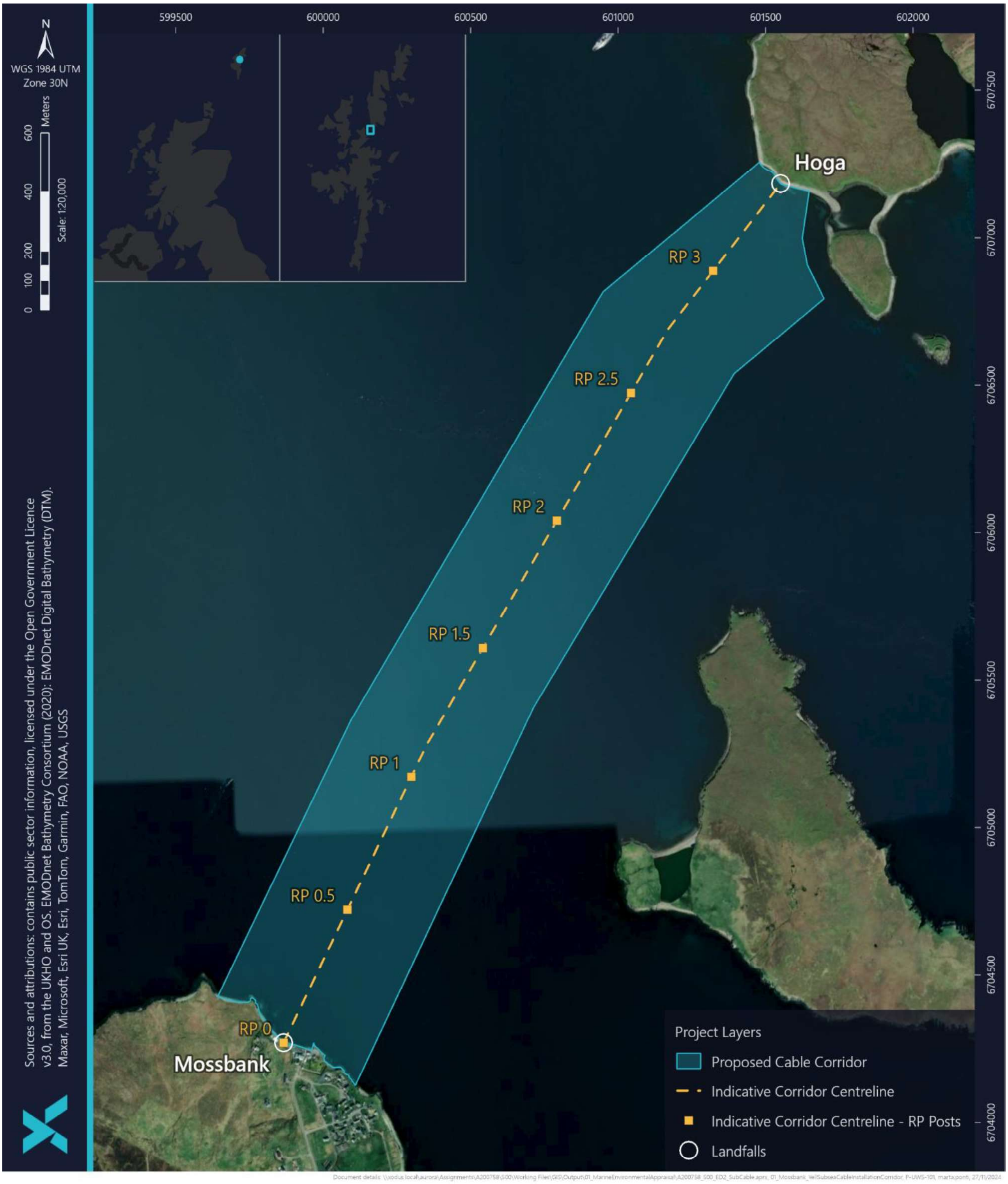


Figure 1-2 The Mainland Shetland (Mossbank) – Yell (Hoga) Proposed Cable Corridor (Note: indicative corridor centreline does not depict proposed cable route but is provided for spatial referencing within the proposed cable corridor, in combination with the Reference Points (RPs)).

1.2 Summary Scope of Work

This document provides details of the following activities and scopes of work:

- Pre-installation surveys to identify debris / obstructions, where required;
- Pre-Lay Grapnel Run (PLGR), where required;
- Removal of OoS cable(s) in the intertidal area to facilitate installation of the replacement cable, where required;
- Landfall establishment;
- Cable installation;
  - The subsea cable will be surface laid below Mean Low Water Springs (MLWS),
  - In the intertidal zone, cable installation will be via open cut trench between MLWS and Mean High Water Springs (MHWS) at each landfall location;
- Cable protection and stabilisation installation;
  - Cable protection measures may include split pipe, rock bags and concrete mattresses,
  - Sea earths and associated protection will also be required;
- Landfall re-instatement; and
- Post-installation surveys.

1.3 Project Need

The existing Mossbank – Yell North 1 subsea cable between Mossbank and Yell faulted in May 2024. The network has been reconfigured to supply Yell, Unst and Fetlar via one remaining subsea cable link (Mossbank – Yell North 2), and mobile back-up generation has been deployed to these islands. SHEPD therefore proposes to install a replacement subsea cable that will connect Mainland Shetland at Mossbank to Yell at Hoga, via the existing network tie-in points at each landfall.

1.4 Consideration of Alternatives

Following the subsea cable fault, the following options were considered in order to restore grid connection to Yell:

Option 1: Do Nothing (Customers continue to be supplied via alternative subsea cable). This was discounted as a viable option due to customers on three of the Northern Shetland Isles will be reduced to single cable supply. Should this single cable fail there will be no supply to the Islands of Yell, Unst and Fetlar, until a suitable number and size of generators can be located on the islands. This option would not support SHEPD’s island decarbonisation ambitions and would produce a significant increase in carbon output whilst also reducing the network security for these customers.

Option 2: Piece In Repair. This option has been discounted due to historic survey information which highlights the poor condition of the faulted cable, including outer coating cable damage and armour corrosion throughout the length of the cable. In addition, lifting the cable in its current condition to facilitate the repair may cause further damage which could lead to further faulting. Multiple points of damage were noted on the cable in the routine 2022 inspection, with 40% of the cable unseen which could have further damage. Covered sections would likely require intervention and de-burial resulting in additional detrimental impact to the marine environment.

Option 3: Lay New Shore End (Traditional). This option has been discounted for similar reasons as Option 2. The cable would have to be cut and lifted on to a vessel for jointing which heavily relies on the cable being of good condition to joint and manoeuvre. Fault located mid channel circa 2.6km from Mossbank. Given existing cable damage locations likely to require circa 40 – 50% of the cable to be replaced to remove damage and fault and increase repair success rate. Cable likely to remain at an unacceptable Health Index 5 (HI5) following repair. Multiple points of damage noted on cable in 2022 inspection, with 40% of the cable unseen which could have further damage. Covered sections would likely to require de-burial resulting in additional detrimental impact to the marine environment.

Option 4: End-to-End Replacement. This is the preferred option to be carried forward. This option involves carrying out a full end-to-end cable replacement / installation. Stock 33 kV cable will be installed from a suitable Cable Lay Vessel (CLV) and connected into Transition Joint Pits (TJPs) at both shore ends. The cable will then tie into the existing overhead line (OHL) networks at each landfall via short sections of underground cable.

Option 4 has been determined to be the most cost-effective solution in this situation, despite the expectation that it will be more expensive than a cable repair. This is due to the current condition of the existing cable and the likelihood of success of a repair being low. There is a high probability that even if a repair is successful, a failure may occur within the next three to five years. This will incur further repair or replacement costs, meaning the overall cost of rectifying the issue for the long term is higher.

It has been determined that it will be more beneficial to invest in a full cable replacement that is likely to operate for a minimum 25 years. There is also the added advantage of being a more robust solution as no new subsea joints are introduced into the system. This option will improve the security of supply to the customers on Yell, Unst and Fetlar.

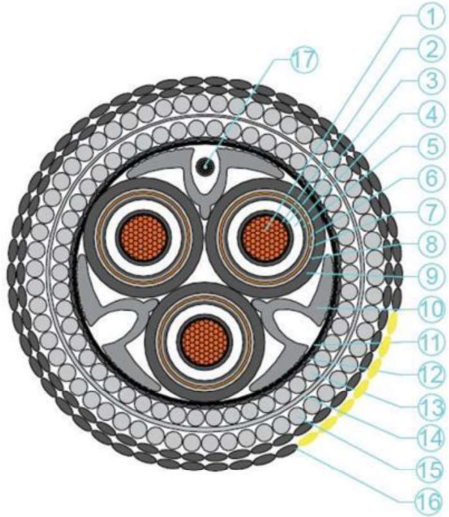
Option 5: Replacement by Horizontal Directional Drill (HDD). A duct is drilled under the seabed between shore ends. The cable is pulled through the duct and connected into TJPs at each shore end. This option has been discounted due to operational feasibility. Maximum installation length of power cable estimated to be limited to ~1.4 km. As the cable route is greater than 3 km, this option is unfeasible. There is also significant potential risk with this option, including unknown ground conditions and stability of sediment once drilling commences.

Decommissioning of the OoS cables. Decommissioning and removal of the faulted cable was considered, however, due to the poor physical condition of the cable within the subtidal area it will remain *in situ* with the exception of those sections required to be removed to facilitate installation of the replacement cable within the intertidal area. Where a cable is in poor condition, cable recovery operations are very difficult due to a lack of mechanical strength and coiling ability. To manage any potential navigation hazard from the old cable, periodic inspections are required to ensure the cable does not pose a risk to environmental receptors or other legitimate users of the sea. Further detail on decommissioning requirements and measures can be found in the OIMD Strategy provided alongside this MEA.

2 PROPOSED CABLE

The purpose of this section is to provide a description and drawings of the proposed 33 kV High Voltage Alternating Current (HVAC) submarine power cable.

The proposed submarine cable consists of a three-core design with copper round compacted stranded conductors (300 mm^2) cross-linked polyethylene (XLPE) insulation and copper laminated tape, polyethylene sheath, polypropylene (PPY) and a double layer of galvanized steel wire armour. It will also feature an integrated Fibre Optic (FO) cable consisting of a bundle of 48 optic fibres, polyethylene sheaths, and steel armouring. The cable is rated at 33 kV with an outer diameter of approximately 141.6 mm and weight of approximately 30.84 kg/m in water. The proposed cable cross section is shown in Figure 2-1.



1 – Copper round stranded conductor, Class 2, compressed and water blocking compound
2 - Semiconductive water blocking binder tape.
3 – Conductor screen semi-conductive compound
4 - Insulation: TR-XLPE.
5 – Insulation screen: semi-conductive compound.
6 - Semiconductive water blocking tape.
7 - Metallic sheath: copper tapes.
8 – Semi-conductive water blocking tape.
9 – Inner sheath: SCPE.
10 – Filler: pre-mould PE.
11 – Binder: woven belt with glue tape.
12 – Serving: PP yarn.
13 – Armour: galvanised steel wires and bitumen.
14 – Bedding: nylon tape
15 – Armour: galvanised steel wires and bitumen
16 –Outer sheath: PP yarn (yellow and black)
17 – Armoured Optical unit of 13 mm approximate diameter containing 48 optical single mode fibres

Figure 2-1 Proposed Cross Section of the XLPE Submarine Cable

3 PREVIOUS SEABED SURVEYS

SHEPD appointed a contractor in 2018 to conduct geophysical and drop-down video benthic surveys of the proposed cable corridor. The main objectives of the marine surveys were to:

- Provide data (both technical and environmental) to form the basis for preliminary route engineering for the proposed cable; and
- Assess potential risks to the cable from local seabed influences including boulders, crossings, debris, freespans, trawl scars, etc.

These surveys were undertaken within the installation corridor. Further pre-installation surveys may be required to inform detailed cable route engineering (details are provided in Section 4.3.1).

4 PROJECT OVERVIEW

4.1 The Proposed Cable Installation Corridor

The maximum length for the proposed cable will be approximately 4 km between Mossbank MHWS and Yell MHWS. This cable length allows for obstacle avoidance during the cable lay and tolerances with the cable lay operations. If required, debris or obstructions may be cleared as discussed in Section 4.3.2, however, if debris/obstructions cannot be removed from the planned route, the cable will be micro-routed around them. At all times the works and final cable placement will stay within the proposed cable installation corridor.

The proposed cable installation corridor is shown in Figure 1-2, with landfalls located at Mossbank, Mainland Shetland and Hoga, Yell. The selection of the installation corridor was based on the avoidance of environmental constraints, whilst ensuring it will be technically feasible to install a cable within it. An assessment for cable on-bottom stability within the proposed cable installation corridor will form part of the detail routed engineering deliverables. Cable on-bottom stability will be assessed through the computational analysis of the cable cross-section, selected marine cable route corridor and historical and current wave data for this region.

4.2 Vessels

4.2.1 Cable Lay Vessel (CLV)

The Seacor Nile (Figure 4-1) or a similar vessel will be the main CLV for this Project. Seacor Nile is a specialist CLV that was built in 2019. She is a DP2 class vessel so is able to hold station using her thrusters, without the need for anchoring. The specifications for this vessel are detailed in Table 4-1.

Figure 4-1 Seacor Nile, example of a CLV that may be used during the Project

Table 4-1 Seacor Nile – Key Information

PARAMETER	MEASUREMENT
Gross Tonnage	4,125 tonnes (t)
Dimension – Length	85.7 m
Dimension – Beam	18 m

4.2.2 Dive Support Vessel (DSV)

The Forth Warrior (Figure 4-2) or a similar vessel will be used as the Dive Support Vessel (DSV) for this Project and will help in conducting PLGR should it be required. Forth Warrior is a general utility vessel and the specifications for this vessel are detailed in Table 4-2.

Table 4-2 Forth Warrior - Key Information

PARAMETER	MEASUREMENT
Gross Tonnage	296 t
Dimension – Length	27 m
Dimension – Beam	12 m

Figure 4-2 Forth Warrior, example of a DSV that may be used during the Project

Station Keeping

If the Forth Warrior is used, this vessel may be able stay on location using Dynamic Positioning (DP), although not during diving operations where she will use her spud legs or anchor spread. It is most likely that the DSV will be the Forth Warrior, however, included below in Table 4-3 are spud leg dimensions of some larger vessel in the instance that these are required instead of the vessel described above.

Due to the differing length of the spud legs, depth limits for each vessel (assuming flat calm conditions) are also noted in Table 4-3.The exact number of spud placements on the seabed is difficult to determine for the following reasons:

- Weather may interrupt a period of work, so multiple days of spud leg deployment may be required for a single task;
- Vessel may not achieve good seabed hold on first attempt so may need to repeat spudding down; and
- Once in position, vessel may need to change heading, therefore would require to-lift and lower at least one spud.

Nonetheless, to allow for a worst case scenario it is assumed that one spud barge movement (4 spud legs) is required per day at each landfall during split pipe installation and cable pull in operations (12 days).

Table 4-3 Spud Leg Parameters and Working Limits for Example Vessel

VESSEL	SPUD DIAMETER	DEPTH LIMIT (LOWEST ASTRONOMICAL TIDE (LAT))
Forth Warrior	610 mm with spiked tip	< 13 m
Forth Drummer	508 mm with spiked tip	< 10 m
Harry McGill	914 mm with spiked tip	< 14 m
Forth Atlas	914 mm with spiked tip	< 15 m

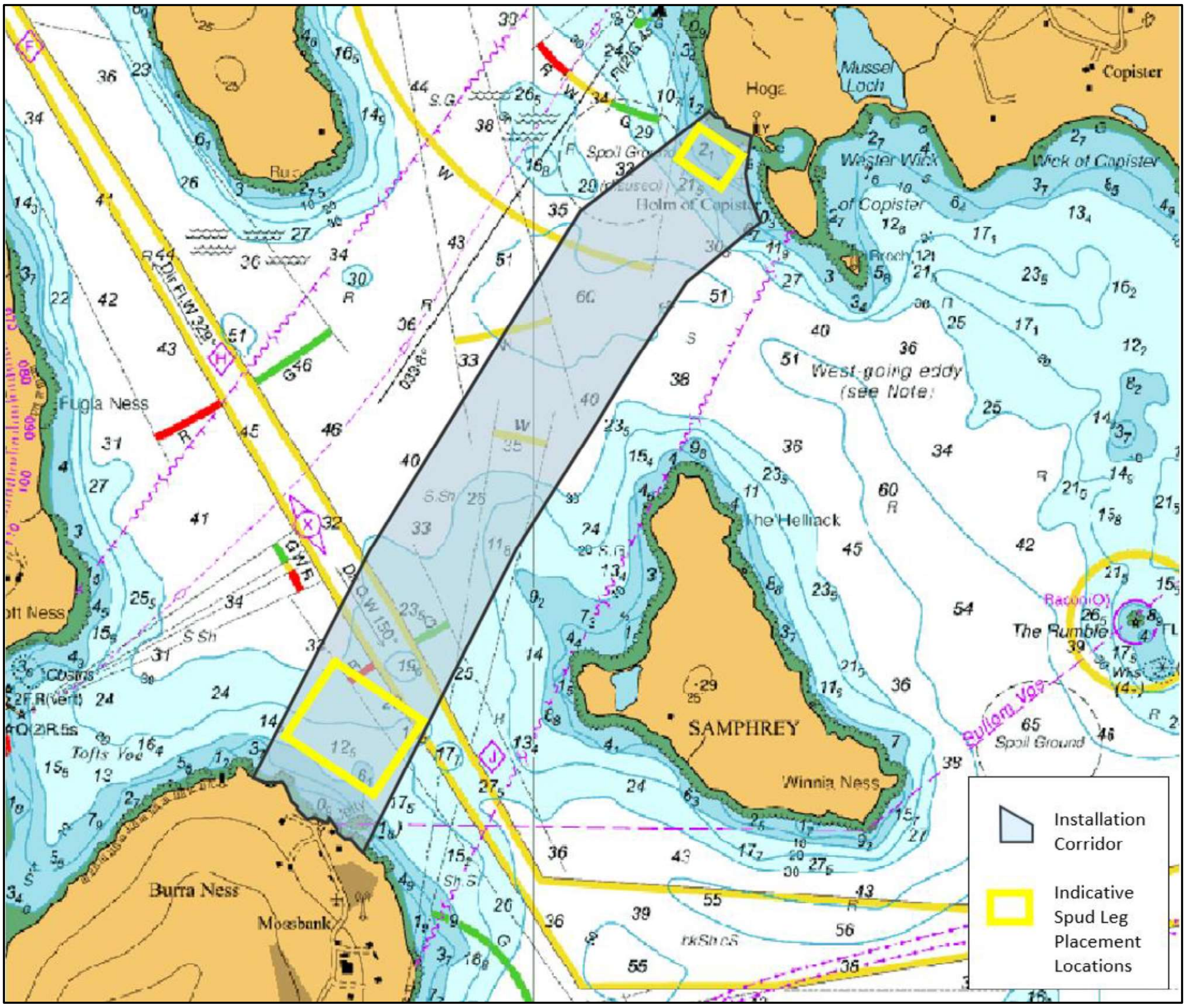


Figure 4-3 Indicative Spud Leg Placement Locations within the Installation Corridor

The DSV may alternatively be positioned using a mooring spread of up to 4 anchors. A diagram of a 4-point mooring design is included in Figure 4-4. Delta Flipper Anchors with a footprint of 6.2 m^2 and weight of 2 t each will be used to anchor the mooring spread.

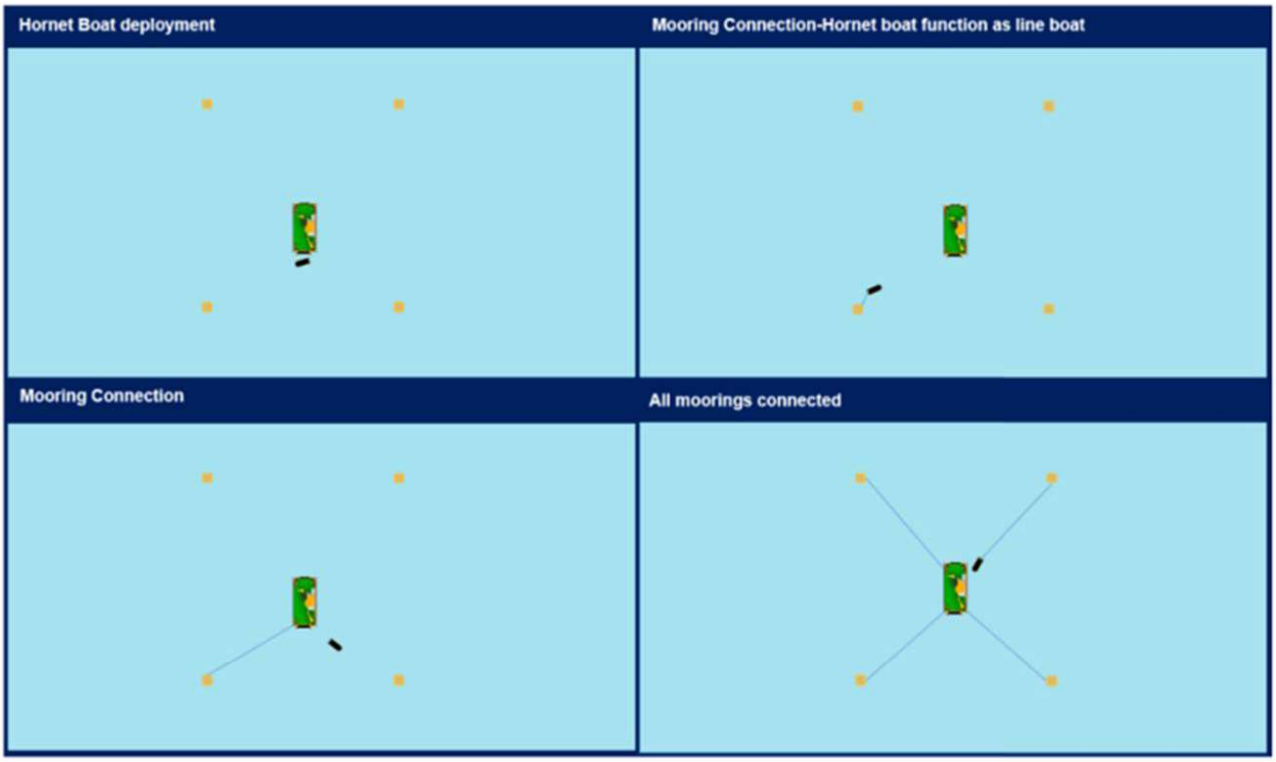


Figure 4-4 Diagram showing a 4- Point Mooring design

4.2.3 Other Support Vessels

Landing Craft

The Toplander, or similar, landing craft (see Figure 4-5) may be required for potential delivery of shore end plant equipment. Key vessel information for the Toplander landing craft is detailed in Table 4-4 .

Table 4-4 Toplander – Key Information

PARAMETER	MEASUREMENT
Gross Tonnage	540 t
Dimension – Length	22.1 m
Dimension – Beam	7.5 m

Figure 4-5 Example shore end landing craft - Toplander

Cable Protection and Stabilisation Support Vessel

The Hydro Patriot (Figure 4-6) or a similar offshore supply vessel, may be used for the installation of rock bags, if required. Key vessel information for the Hydro Patriot is detailed in Table 4-5.

Table 4-5 Hydro Patriot – Key Information

PARAMETER	MEASUREMENT
Gross Tonnage	2,532 t
Dimension – Length	73 m
Dimension – Beam	16 m

Figure 4-6-Example of rock bag installation vessel, Hydro Patriot

Small Support Vessels

The Celtic Guardian (Figure 4-7) or a similar vessel may be used to provide general support to the installation activities. Celtic Guardian is a 14 m general purpose inshore vessel with a 4 m beam.

Figure 4-7 Celtic Guardian, example of a support vessel that may be used during the Project

4.3 Pre-Installation Activities

4.3.1 Pre-Installation Survey

Before cable installation commences, a pre-installation survey may be conducted using a Remotely Operated Vehicle (ROV) to assess seabed conditions and the presence of debris. If required, survey operations will likely be conducted from a small vessel, such as the Celtic Guardian before the CLV arrives (Figure 4-7).

The objectives of the survey will be to:

- Identify and investigate possible debris; and
- Identify any obstructions as well as environmental and other sensitivities within the installation corridor.

During installation a similar survey spread may also be utilised to monitor the installation process. Alternatively, an ROV may be deployed from the CLV or other support vessel and operate touchdown monitoring and ROV surveys from this platform. The below ROV and survey equipment are examples of the type of equipment that may be used- exact models may vary, however, all equipment used will fall within the requirements set out within the EPS Licence Application for the Project. Table 4-6 summarises details of other survey equipment which may be used in the proposed cable installation activities.

Figure 4-8 Example of Possible Survey Vessel and (2) Example ROV that may be used during the Project

Table 4-6 Examples of Proposed Survey Equipment that may be used during the Project

SYSTEM / SURVEY EQUIPMENT	DESCRIPTION
Geophysical Survey	
Ultra-Short Baseline (USBL)	USBL systems are used to determine the position of subsea survey items, including ROVs, towed devices, grab samplers, etc. This involves the emission of sound from a vessel-mounted transducer to a subsea transponder, thereby introducing sound into the marine environment. A USBL system consists of a transducer, which is mounted on the vessel and a transponder attached to the ROV. The transducer transmits acoustics through the water and the transponder sends a response which is detected by the transducer. The USBL calculates the bearing and time taken for the transmissions to be completed and thus the position of the subsea equipment is determined. These systems can either be used continuously or intermittently through the operation they are supporting.
Multibeam Echosounder (MBES)	MBES is a device used to obtain detailed three-dimensional (3D) maps of the seafloor which show water depths. They measure water depth by recording the two-way travel time of a high frequency pulse emitted by a transducer. The beams produce a fanned arc composed of individual beams (also known as a swathe). MBES can, typically, carry out 200 or more simultaneous measurements.
Seabed Imagery	
Hi-Resolution Camera	An ROV mounted camera will be utilised to acquire imagery of the cable and adjacent seabed.

4.3.2 Pre-Lay Debris Removal

Any obstructions or debris identified during the surveys which cannot be avoided may be removed. This may be achieved by conducting a PLGR in order to remove debris from the proposed installation corridor. Any boulders within the working area will be avoided where possible. If boulder clearance is however required, the boulders will be placed within the cable corridor but clear from the cable route. If large boulders are relocated within the cable corridor, appropriate notifications (including original and final positions) to marine users will be provided.

The PLGR will aid to clear the installation corridor of debris such as OoS cables, chains, wires, ropes, and fishing gear. If PLGR is required, it is expected that this activity will be completed shortly in advance of the cable installation activities to ensure that the installation corridor remains free of debris prior to installation. The PLGR will be towed along the centre line of the new cable route (up to 3 m from the centre line), and as such no seabed disturbance beyond the cable installation footprint is anticipated.

When on site, the vessel will manoeuvre into the start position and overboard the appropriate grapnels for the reported seabed conditions. When in position, the vessel will proceed along the designated cable route at a slow speed (≤1 knot). Tow tensions will be monitored during the PLGR, if a steady increase in tow tension is observed, the vessel will be brought to a stop, and the grapnels recovered to deck. Debris will be cleared from the grapnels and stored onboard the vessel, before redeploying and resuming the PLGR. All recovered debris will be taken ashore and sent for appropriate recycling or disposal at a licenced waste handling facility. Typical grapnel trains are shown below in Figure 4-9.

If required in the intertidal areas, debris removal is likely to be conducted at low water, when the area is exposed, either by hand or using mechanical plant depending on the size and nature of the debris. It is possible that a diver may be required to remove debris if tidal working from shore is not possible.

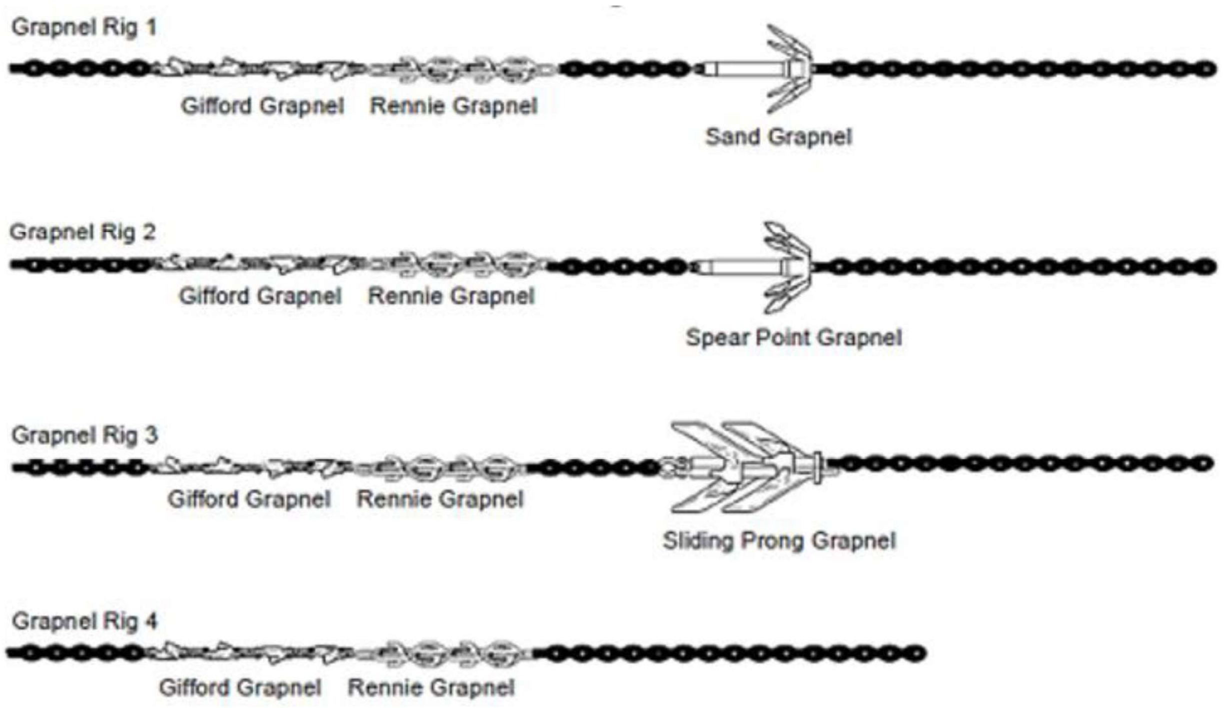


Figure 4-9 Typical Grapnel Trains

4.3.3 Removal of OoS cables

OoS cables may be removed in the intertidal area at the Yell landfall to allow the new cable to be installed in the best approach angle. The worst-case would be the removal of 100 m of the faulted cable within a 30 m corridor:

- Yell: Up to 100 m; and
- Mossbank: Not applicable – the Mossbank landfall of the 2009 (Mossbank – Yell North 1) faulted cable lies outside of the proposed cable corridor and as such, no removal of this OoS cable is proposed at the Mossbank landfall.

4.4 Installation Methods – Intertidal

4.4.1 Open Cut Trench -

In the intertidal areas between MHWS and MLWS, where ground conditions allow burial, the cable will be buried at both landfalls using Open Cut Trench (OCT) method (refer to Figure 4-10 as an example of this method). This will be conducted using conventional land-based excavators working within a tidal window, i.e., when the intertidal area is exposed, avoiding works below the waterline. A landing craft may be used to access the landfall sites if the shore conditions permit. If required, the vessel will be used to mobilise and demobilise equipment that will be used during the installation works.

Temporary shoring, such as trench boxes, may be required to prevent the collapse of trench walls. The excavated material will be placed to one side of the trench and stored for later reinstatement. General working areas and layouts at the Mossbank and Yell landfalls are provided in Figure 4-11 and Figure 4-12, respectively.

The width of the trench is expected to be approximately 1 m; however, this may be increased depending on the stability of the soils. The target depth will be to the top of the cable at approximately 800 mm below ground level, depending on sub surface sediment makeup. A rock pecker may be utilised to achieve burial depth where the sub-surface is rocky. Alternatively, additional split pipe may be utilised on sections where burial depth cannot be practicably achieved.

One trench will be required at each landfall down to MLWS. This will contain the new power cable plus two earth wires. At MLWS the two earth wires will separate and continue on the surface of the seabed for up to 50 m. It is anticipated that a 20 m wide working corridor will be required for each trench, accounting for the footprint of the excavator and the temporary storage of excavated material. Table 4-7 details the requirements for the trenching activities.

On completion of OCT activities and installation of the cables, thermal sand may be used to cover 75 mm with a maximum weight of ~ 25 t, prior to backfilling the trenches using native material from the excavation.

Table 4-7 OCT Trench Requirements

LOCATION	TRENCH PURPOSE	WORST-CASE CABLE BURIAL LENGTH (m)	TARGET DEPTH, TOP OF CABLE (mm)
Working corridor for all OCT is 20 m wide			
Mossbank MHWS to MLWS	Cable + 2 Earth wires	50	800
Yell MHWS to MLWS	Cable + 2 Earth wires	50	800
Additional Requirements	Where required, thermal sand will be used to cover 75 mm around the cable. The sand will have a weight of approximately 25 t.		
***A 10% contingency has been applied to these values to represent worst-case.**			

Figure 4-10 Example of OCT Cable Burial

Figure 4-11 Landfall general working area at Mossbank, Mainland Shetland

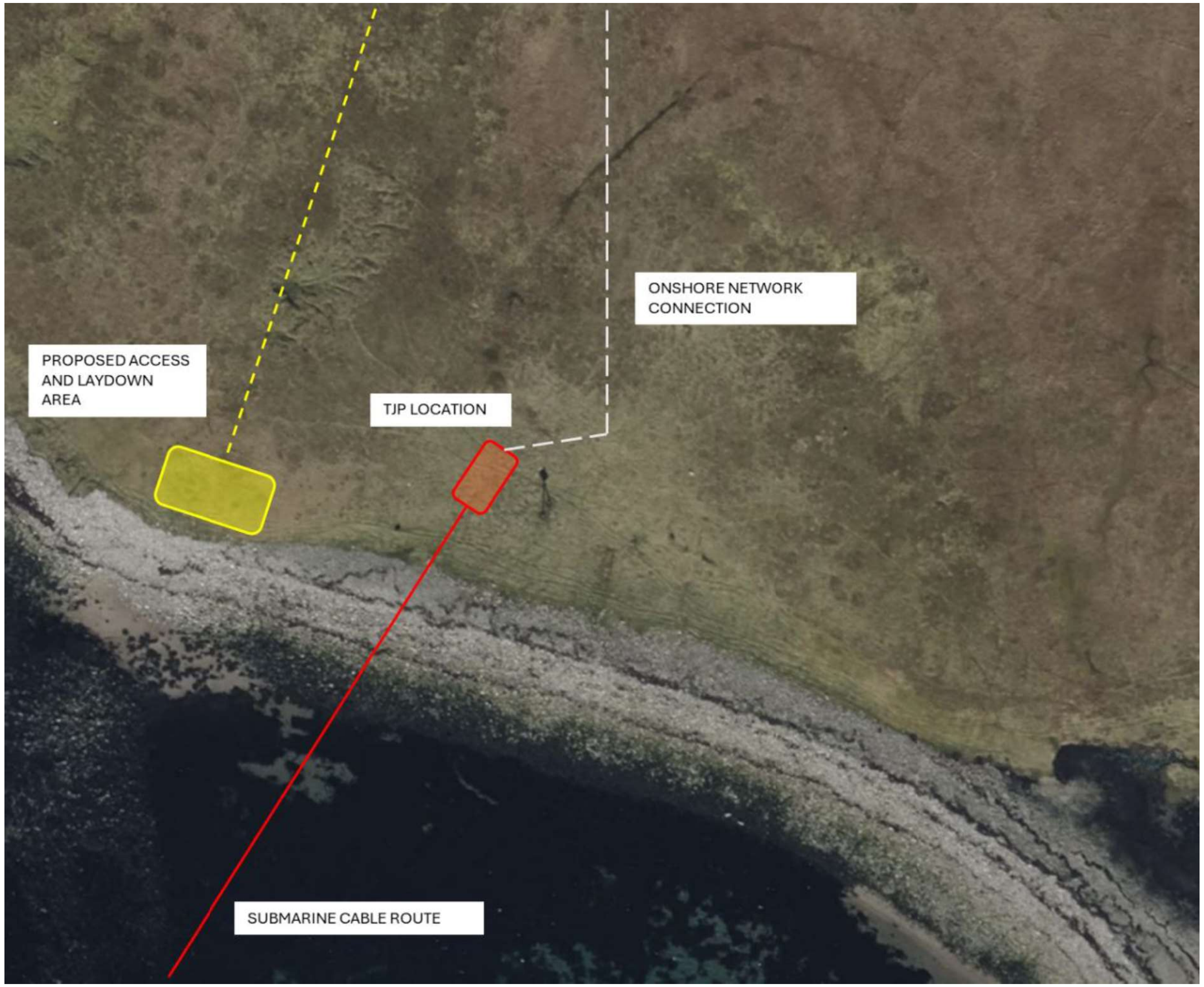


Figure 4-12 Landfall general working area at Hoga, Yell

4.4.2 Cable Pull-In

Winches will be mobilised to the landfall areas in order to facilitate pulling the cables ashore. These winches will be located onshore above the MHWS. A combination of rollers (Figure 4-13) and quadrants (Figure 4-14) are used to ensure the cable is not damaged and follows the correct alignment during the pull-in process through the intertidal area. Rollers support the cable and reduce friction, while quadrants are used to facilitate changes in direction. They can either be held in position using land plate anchors or anchored on an excavator. The rollers and quadrants are temporary aids to installation, and will be removed entirely following the completion of the pull-ins.

Figure 4-13 Examples of Rollers

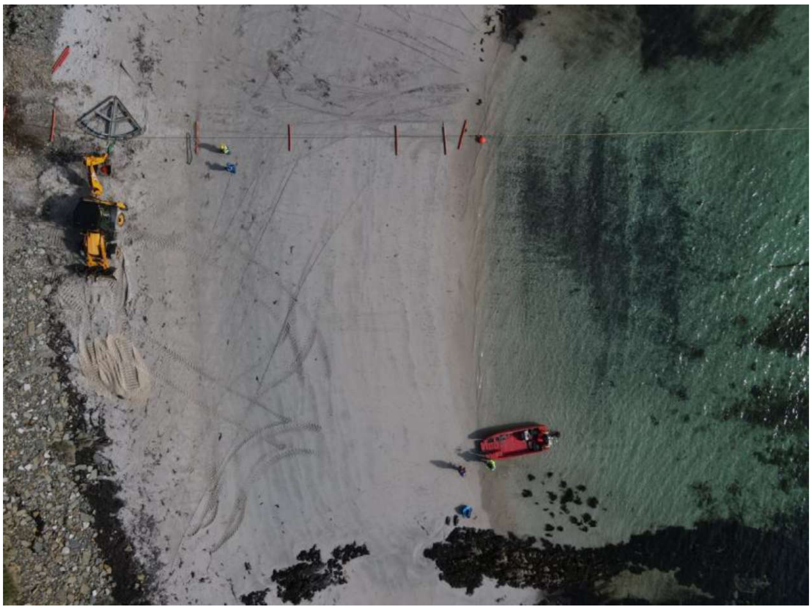


Figure 4-14 Example of Rollers and Quadrants

A messenger wire will be taken ashore from the CLV by small craft and connected to the shore winch wire at low water. The mooring line and winch wire will be pulled back to CLV and connected to the cable end. The shore winch will then pull the cable ashore with floats being attached to the cable on CLV and removed as the cable reaches low water. The floating cable may be held in position by a support vessel as required. The cable will then travel through the intertidal area, via the rollers and quadrants until it reaches the TJP where it is secured. At this point, any remaining cable floats can be removed from shore towards the CLV, completing the pull-in operation.

At the second end the pull-in will be achieved using a floating bight of cable. On approach to the second end, floats will be connected to the cable while support craft ensure the cable is held securely within its design limits until the CLV has paid out enough floating cable to reach the TJP, such that the cable can be cut and sealed. Once this is done, the cable end will be taken ashore by support vessel where it will then be connected to the shore winch. The shore winch will pull the cable end towards the TJP. During this phase, support craft will manipulate the floating cable bight, within its limits, to ensure that the cable end pulls directly to shore and the cable is pulled straight. Once the cable end reaches the shore winch, the initial pull is completed. Floats will be removed from the CLV towards shore, with the shore winch pulling in any slack that is created to complete the installation process. An example of a cable being pulled to shore in shown in Figure 4-15.

Figure 4-15 Example of Cable being Pulled to Shore

4.5 Installation Methods – Subtidal

4.5.1 Cable Laying

The cable will be surface laid along the entire length of the subtidal section of the installation corridor (MLWS to MLWS), this will be achieved by using a CLV. Smaller support vessels may also be used in the shallower shore locations. There will also be a DSV that may utilise a mooring spread (anchors) or spud legs to hold station in the nearshore area (refer to Section 4.2.2), and a guard vessel may be required during the cable lay operations in order to ensure other vessels remain outside the area of operations to reduce collision risk.

The reason for surface laying the proposed cable is that the surveys of the proposed cable installation corridor indicate that it does not have good burial potential along the majority of its length.

Once the pull in is complete (Section 4.4.2), the CLV is set up and catenary established to the sunken cable, the cable lay can then commence. The vessel shall then proceed to lay the cable as it moves away from the landfall. Touchdown monitoring will be conducted using an ROV deployed from the CLV or other support vessel, or Cable Fish which will monitor the lay parameters during the installation.

Once the CLV reaches the other landfall, a similar process is conducted to pull the cable ashore and complete the cable laying operations, further detail is provided in Section 4.4.2.

4.5.2 Cable Stabilisation

SHEPD has compiled a list of cable stabilisation materials required, based on survey data acquired from the nearshore and offshore surveys. This conservatively outlines the type (including alternatives) and a worst-case amount of material required for cable stabilisation and forms the basis of the assessment made in the MEA. While the worst-case for each type of material is presented in the following sections, the actual cable stabilisation may be a combination of methods and is subject to further route selection and detailed engineering. The cable stabilisation will be placed where required along the cable route. No burial is planned for any subtidal section of the cable due to a lack of sediment.

While engineering studies are ongoing, which may alter the final types and quantities of cable stabilisation required, the information provided in this project description, and which forms the basis of the assessments in the MEA, are based on anticipated realistic worst-case scenario and include a 10% contingency.

Rock bags and concrete mattresses may be required for cable stabilisation.

Rock Bags

The cable installation strategy includes the installation of rock bags onto the cable to provide stability. If rock bags are used, they will mostly be installed below 8 m Lowest Astronomical Tide (LAT) and within 3 m either side of the installed cable. The LAT limits will be determined by the size of the rock bags, as follows:

- Minimum 8 m LAT: 2 t rock bags; and
- Minimum 12 m LAT: 4 t rock bags.

The 8 m LAT threshold is derived by ensuring that the navigable water depth has not been reduced by >5%; the 2 t rock bags are 400 mm tall when installed. There may however be the requirement to place rock bags <8 m LAT but this will be avoided where possible. In such instances advice from the Marine and Coastguard Agency (MCA) and other navigational bodies will be sought and considered. An example image of 2 t rock bag is provided in Figure 4-16.

The 2 t, or 4 t rock bags which may be installed have a diameter between ~2.2.m (2 t) and ~2.8 m (4 t). Rock bags would potentially be positioned on top of the cable and/or on either side of it. The potential numbers required (including contingency) is 90 no. 2 t rock bags (180 t collectively), and 40 no. 4 t rock bags (160 t collectively). Where depths allow, some 2 t rock bags may be replaced with 4 t bags, however this will not exceed the overall seabed footprint affected. The formation of rock bag installation would typically be in pairs, one either side of the cable at required intervals to maintain on-bottom stability.

Installation of rocks bags would either be from the CLV deck, a separate large installation vessel with ROV, or multicat vessel.

Figure 4-16 2 t Rock Bags

Mattresses

If concrete mattresses were to be used, they would most likely be installed below 6 m LAT and within 3.5 m either side of the installed cable. The 6 m LAT threshold is derived by ensuring that the navigable water depth has not been reduced by >5%; the mattresses are 300 mm high when installed. There may however be the requirement to place mattresses <6 m LAT even though this will be avoided where possible. In such instances advice from the MCA and other navigational bodies will be sought and considered.

The 300 mm thick concrete mattresses are nominally 6 m long by 3 m wide and weigh 8.75 t each. The formation of mattress installation would typically be on top or on either side of the installed cable. Maximum potential numbers required in the event of contingency is 20 concrete mattresses which equates to 175 t collectively. This maximum number represents a scenario where concrete mattresses would be used as the primary method of cable stabilisation. Installation of mattresses would either be from the CLV, a large installation vessel with ROV or multi-cat vessel. A work class ROV operated mattress frame will be utilised for the installation of concrete mattresses at the crossing locations. A multicat type vessel will carry out the installation in shallow water, holding position using spud legs or anchor spread to position the mattresses along the route of the existing cable.

4.6 Sea Earths

Sea Earths will also be installed to provide protection from surges and lightning strikes to the electrical circuit. It is expected that two earthing cables will be required at each shore end using copper wires with a cross sectional diameter of 70 mm^2. One cable will earth the armour of the HVAC cable system, while the other provides an earth for the FO armour (integral to the HVAC cable system (refer to Figure 2-1). The earthing wires will be installed in the OCT alongside the new cable above MHWS, and at MLWS the two earth wires will separate and continue on the surface of the seabed for up to 50 m.

4.6.1 Clump Weights

Up to 10 concrete clump weights (at a maximum of 60 kg each) at each landfall may be used to anchor the sea earths at intervals / at their termination subsea. If used intertidally, they would be completely buried along with the sea earth. In the subsea section (max 50 m beyond LAT), the earth would be on the seabed surface and may be protected by clump weights.

4.6.2 Rock Anchors

Up to 20 rock anchors (2 kg each) for the subsea earth may be used, in lieu of clump weights, where it is understood to be a harder seabed with less sediment cover. In instances where rock anchors are required, a diver would drill a hole in the rock (max 20 mm diameter, 200 mm depth) and insert a small volume of marine grade resin and a stainless-steel anchor.

4.7 Split Pipe

Split pipe (also referred to as articulated pipe) is commonly used on cable shore ends and beach landings, as well as subtidal sections of cables. It consists of a series of approximately 0.3-0.4 m long half pipe sections of iron which clamp around the cable and interlock, providing mechanical protection, a flexible connection and bend restriction. Various types of split pipe are available, but most typically have an external diameter of approximately 260 mm.

Split pipe can be applied during the shore end installation, being fitted on the CLV whilst the cable is being paid out or retrofitted at low tide. Split pipe can also be installed by divers in the subtidal area using a DSV (section 4.2.2), in which case it is likely that the articulated pipe will be retrofitted. If divers are used to install split pipe, the DSV will either hold station using spud legs or a mooring spread, as detailed in Section 4.2.2. Additional protection afforded by split pipe will be incorporated into the route engineering with respect to both shore end landfalls and out to include the nearshore subtidal rocky outcrops and boulder fields. On either shore above the MLWS limit, where sufficient cable burial cannot be achieved, split pipe will be fitted around the cable for additional protection in the event of exposure as detailed in Section 4.4.1.

An example of a split pipe diagram is shown in Figure 4-17 and installation method in Figure 4-18.

Figure 4-17 Split Pipe

Figure 4-18 Split Pipe Installation

It is anticipated that split pipe will be installed in the following areas by the methods outlined below, although this may be subject to change following detailed engineering, with a summary provided in Table 4-8:

- Mossbank intertidal area to subtidal areas: the worst case is to install a total of up to 200 m of split pipe. The purpose of the split pipe is to protect the cable in an areas of wave action on hard seabed and to provide provision of extra weight to the cable, thus making it more stable across the hard seabed.
- Yell intertidal and subtidal areas: the worst case is to install up to 200 m of split pipe to protect the cable in areas of wave action on hard seabed and to provide provision of extra weight to the cable, thus making it more stable across the hard seabed.

Table 4-8 Split Pipe Requirements

SITE LOCATION	LOCATION	WORST-CASE SPLIT PIPE REQUIREMENTS (m)
Mossbank	Intertidal and subtidal areas	200
Yell	Intertidal and subtidal areas	200
	TOTAL	*400*
	TOTAL (+ 25% Contingency)	*500*

4.8 As-built Survey

Installation data will be compiled to confirm the as-built positions, and to ensure that the design and licence requirements have been met. Details of the as-built locations of the cable and associated protection measures will be provided to the United Kingdom (UK) Hydrographic Office and the Kingfisher Information Service for inclusion on Admiralty Charts, and Offshore Renewable and Cable Awareness Charts respectively.

4.9 Schedule of Deposits

The materials used in installation or removed from below MHWS are detailed in Table 4-9 and Table 4-10.

*Table 4-9 Materials used in installation or removed from the seabed during the Project**

	INSTALLATION MATERIALS		REMOVALS	
Type of Deposit / Removal	**Description**	**Quantity and Dimensions (metric)**	**Description**	**Quantity & Dimensions (metric)**
Submarine Cable	HVAC power cable. Three core design with copper round compacted stranded conductors, XLPE insulation, copper laminated tape and polyethylene outer sheath, including integrated FO cable.	No. 1 Dimensions: • Diameter: 141.6 mm; and • Length: 4,000 m. Weight: 30.84 kg/m	HVAC power cable. Three core design with copper conductors, EPR insulation, and polyethylene outer sheath. Removal of faulted cable within the Yell intertidal area.	N/A Dimensions • Diameter: ~132.4 mm; and • Length: ~100 m. Weight: ~ 13.3 kg/m
Earthing wire	Copper wire for earthing.	No. 4 Dimensions: • Diameter: 11 mm; and • Total Length: 700 m. Weight: 0.591 kg/m	N/A	N/A
Cast Iron Split Pipe	Articulated cast iron shell design that interlocks around the cable and is fixed with bolted end clamps. This will be placed in the intertidal and subtidal sections of the cable ends.	No. 1670 Dimensions: • Diameter: 260 mm; • Length of each shell: 0.3-0.4 m; and • Total Length: ~500 m. Weight: 51.3 kg/m	N/A	N/A

	INSTALLATION MATERIALS		REMOVALS	
Concrete Mattresses	Concrete mattresses may be required to stabilise the cable.	No. 20 Dimensions: • Width: 3 m; • Length: 6 m; and • Height: 0.3 m. Weight: 8.75 t each	N/A	N/A
2 t Rock Bags	Rock bags may be required to stabilise the cable.	No. 90 Dimensions: • Diameter: ~2.2 m; and • Height: ~ 0.4 m. Weight: ~2 t each	N/A	N/A
4 t Rock Bags	Rock bags may be required to stabilise the cable.	No. 40 Dimensions: • Diameter: 2.8 m; and • Height: 0.6 m. Weight: ~4 t each	N/A	N/A
Clump Weight	Concrete clump weights for pinning of sea earthing wires.	No. 20 Dimensions: • Diameter: 1 m; and • Height: 0.5 m. Weight: Up to 60 kg each	N/A	N/A

	INSTALLATION MATERIALS		REMOVALS	
Rock Anchors	Stainless steel threaded rod, plus bolt fixing and marine grade resin.	No. 20 Dimensions: • Diameter: ~0.02 m; and • Length: 0.3 m. Weight: 2 kg each	N/A	N/A
Thermal Sand	Initial infill around cable for intertidal trench	Weight: 25 t (4 m of sand per 800 kg bag)	N/A	N/A

Note: material quantities allow for contingency requirements

Table 4-10 Temporary Equipment Below MHWS

TYPE OF DEPOSIT	DESCRIPTION	QUANTITY & DIMENSIONS (METRIC)
Anchors	2 t Delta Flipper Anchors may be used for diving support vessel mooring spread.	Quantity: 4, Diameter: 2.4 m x 2.6 m, Weight: 2 t each
Mooring Chains	Mooring chains will be attached to the anchors for the diving support vessel mooring spread.	Quantity: 4, Diameter 0.03 m, Length: 54 m each, Weight: N/A

5 PROPOSED DELIVERY PROGRAMME

Table 5-1 summarises the indicative schedule of works relating to the proposed cable installation activities. The table shows the expected duration of each activity; however, it should be noted that some may take longer or less days depending on different variables such as weather and/or operational delays. Therefore, the below should be taken as the best estimate. The licence duration being sought by SHEPD is 18 months for contingency in case the installation programme is delayed and cannot be completed before winter.

Table 5-1 Duration of Key Installation Activities

ACTIVITY	DURATION (DAYS)
PLGR and (if required) survey works	5
Cable pull-in operations	2
Offshore cable lay	3
Intertidal works, including trenching, split pipe installation and backfill	10
Installation of offshore protection and stabilisation measures	28
TOTAL	48

6 UXO STRATEGY

Unexploded Ordnance (UXO) are explosive weapons (bombs, shells, grenades, land mines, naval mines, cluster munition, and other munitions) that did not explode when they were deployed and still pose a risk of detonation, sometimes many decades after they were used or discarded. UXO exist worldwide and poses a potentially lethal threat in any area in which they are present. The inherent dangers associated with UXO can largely be attributed to the deterioration of the detonator and main charge, which makes these already volatile components more sensitive to disturbance such as heat, shock and/or friction. Therefore, as part of the route engineering process, a detailed UXO risk assessment within the installation corridor will be carried out and mitigations captured as part of the installation campaign.