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Pentland Firth East (3) Cable Replacement

Project Description

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Project Description

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1. SUMMARY

1.1 Overview

Scottish and Southern Electricity Networks (SSEN) operating under licence as Scottish Hydro Electric Power Distribution plc (SHEPD) is responsible for monitoring and maintaining the efficiency and integrity of the subsea electricity cable networks which provide power supplies to 60 Scottish islands. Two cables (Pentland Firth East and Pentland Firth West) connect Orkney to the Scottish mainland via the island of Hoy. Both cables make landfall at Murkle Bay on the Scottish Mainland and Rackwick Bay on Hoy. The Pentland Firth East (1) cable was identified as being in critical condition and replaced in 2020, however, a fault has since developed on the 2020 replacement cable and it has been determined a new cable will be required to ensure security of supply. At present the previously de-energised Pentland Firth East (1) cable has been reconnected pending installation of the new Pentland Firth East (3) cable. It is proposed that the Pentland Firth East (2) cable installed in 2020 will be decommissioned in as far as this is required in order to facilitate installation of the new Pentland Firth East (3) cable. SHEPD are applying to Marine Scotland for a marine licence to carry out these works.

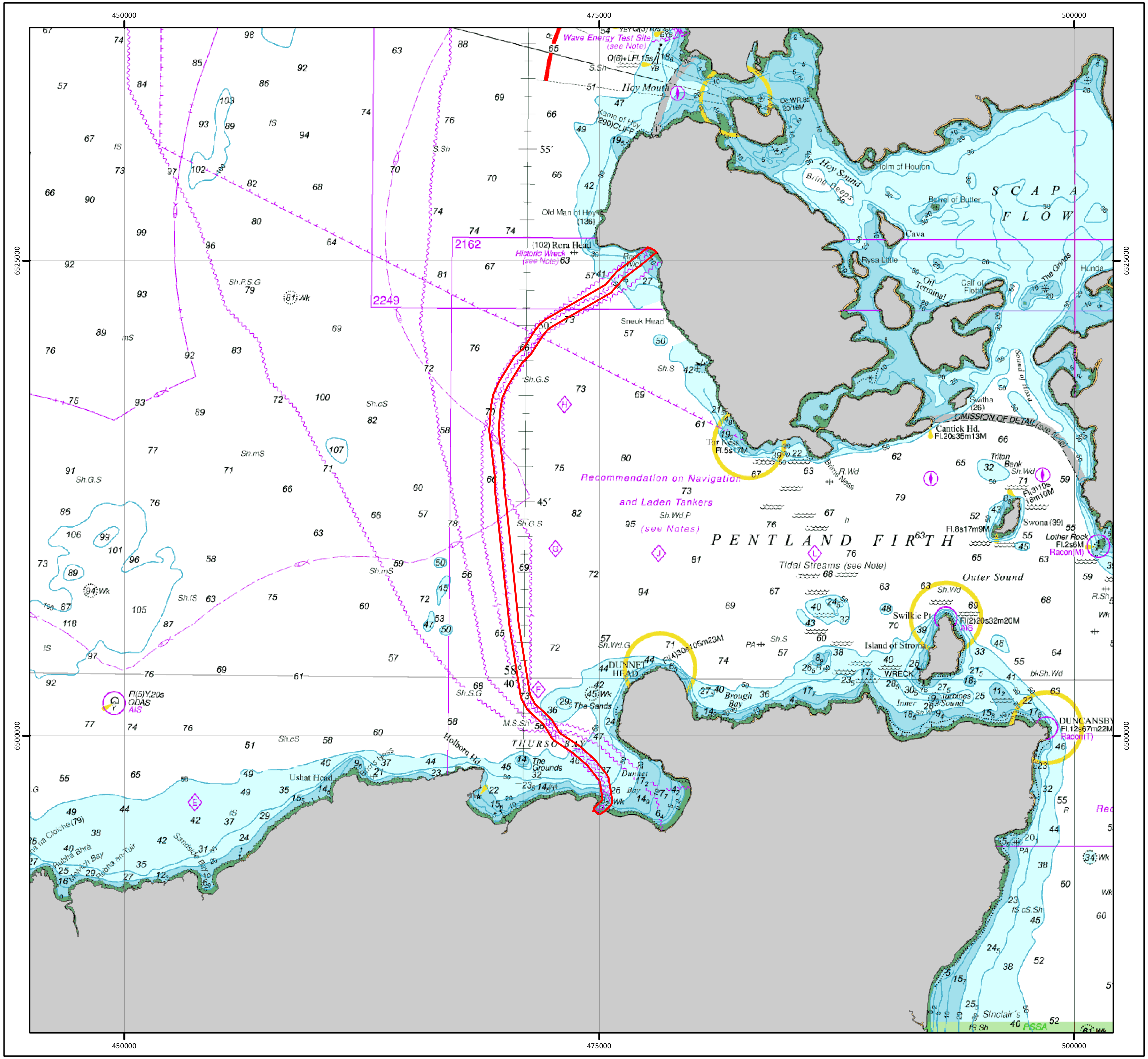
This project description sets out the methodology proposed to undertake the cable replacement works including any required decommissioning activities. The works are scheduled to take place in Q2 to Q3 2023. The estimated time period for each activity is presented below in Table 1-1.

Table 1-1 Estimated installation schedule

Activity	Estimated time period
Cable route preparation	9 days
Cable lay	15 days
Cable burial and stabilisation	41 days
Post lay survey	3 days

1.2 Replacement cable route corridor

The new cable route will be contained within the marine corridor for installation that was consented in 2020 for the Pentland Firth East (2) cable (Figure 1-1 (Drawing reference: P2577-LOC-001)). Along the proposed route, this corridor varies in width between 530m and 780m. The status of the current cable and its planned future are discussed further in the Decommissioning Plan.



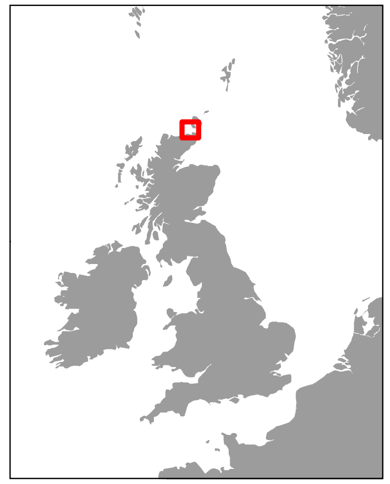
PENTLAND FIRTH CABLE REPLACEMENT MARINE LICENCE SUPPORT

LOCATION OVERVIEW
Cable Route Corridor

Drawing No: P2577-LOC-001 | **A**

Legend

Installation Corridor



NOTE: Not to be used for Navigation

Date	18 November 2022
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	OSOD; MarineFind;
File Reference	J:\P2577\MXD_QGZ\01_LOC\ P2577-LOC-001.mxd
Created By	Emma Kilbane
Reviewed By	Emma Langley
Approved By	Vicky Fisk

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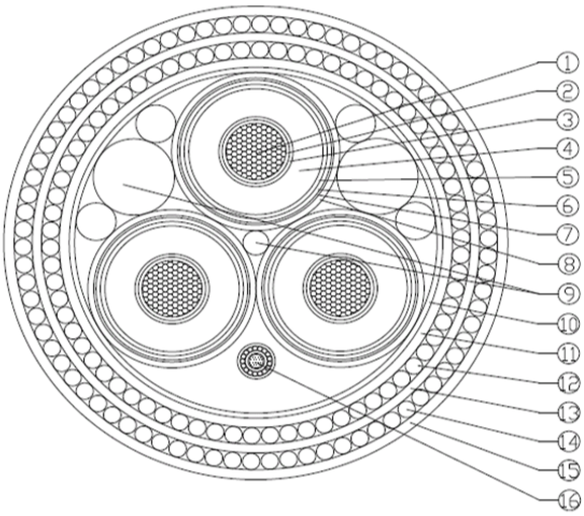
2. PROPOSED CABLE CONSTRUCTION

Electricity will be transmitted using High Voltage Alternating Current (HVAC) submarine cable technology. The typical cable structure is shown below in Figure 2-1.

Figure 2-1 Typical XLPE HVAC submarine cable structure - Cross Sectional Drawing



1 Copper stranded conductors
2 Semiconductive waterblocking tape
3 Non-metallic screen
4 XLPE insulation
5 Non-metallic screen
6 Semiconductive waterblocking tape
7 Metallic screen
8 HDPE sheath
9 Non-hydroscopic fillers
10 Binding tape
11 PPY separator layer
12 Inner layer of galvanized steel armouring
13 PPY separator layer
14 Outer layer of galvanized steel armouring
15 PPY outer layers
16 Fibre optic

The 33kV subsea cable proposed for installation is a 500mm^2 three core stranded copper conductor, XLPE (cross-linked polyethylene) insulation with a 48 fibre optic cable, encased within a double layer of 6mm steel wire armour. The proposed double wired armour (DWA) construction will provide the cable with additional mechanical protection and weight. Fibre optics are installed which are considered integral to the power cable for the purpose of cable condition monitoring, control and power systems protection.

The subsea cable conductor cores specification and power rating has been selected through the assessment of historic demand on the existing network and with consideration given to future demand growth on the network.

A summary of the key mechanical properties of the replacement cable is provided in Table 2-1.

Table 2-1 Proposed Cable – Example Key Mechanical Properties

Cable Weight (in Air) kg/m	Max Tension (kN)	MBR (m)	Cable Diameter (mm)	Max Crush Resistance (kN/m)	Specific Gravity
51.7	215 => MBR above 3mtrs	2.3	154.7	40	~2.7

Prior to installation, dynamic simulations will be conducted of the proposed installation methodology, taking into account the mechanical parameters of the cable, Table 2-1 presents typical parameters for the type of cable being installed. The outputs of this analysis will be a set of operational weather parameters the installation will adhere to. On-Bottom Stability analysis will also be undertaken to ensure the cable is stable on the seabed.

3. SURVEY WORKS

3.1 Pre-installation

Pre-installation survey works were undertaken in August and September 2019 for the 2020 installation. Except for a pre-installation route verification survey, no further marine surveys are anticipated to be required due to the short period of time between installation operations. The surveys included the following operations:

- Offshore geophysical survey;
- Offshore geotechnical and environmental survey;
- Nearshore geophysical survey; and
- Landfall geotechnical and topographic survey.

The key outputs of the surveys were as follows:

- Seabed bathymetry and land topography;
- Soil classification and strength along the proposed cable route;
- Benthic sampling to support classification of existing marine habitats;
- Identification of archaeological features along the proposed cable route; and
- Identification of hazards (debris, existing cables etc.) along the route.

The original survey works enabled identification of the subsea cable installation corridor and informed routing of the 2020 replacement cable. The data will be used to engineer the route for the new replacement cable.

The survey works have also informed the environmental assessment provided in the Environmental Supporting Information (ESI) report (Document Reference P2577_R437).

3.2 Other surveys

As well as the route verification survey, there will also be progress surveys conducted during installation works to verify the work that has been completed. Once all installation activities have been finished an as-laid survey will be conducted to confirm the final position of the cable on the seabed.

4. CABLE PROTECTION AND STABILISATION

4.1 Overview

An overview of the cable protection measures licenced for the Pentland Firth East (2) is contained in Table 4-1. The original amounts were calculated based on preliminary survey data acquired from the nearshore and offshore survey vessels from the 2019 survey.

Table 4-1 conservatively outlines the type and number of seabed deposits required as part of the marine licence and is the basis of the assessment made in the ESI.

Engineering studies are ongoing which may alter the final quantity of deposits required and the information provided in the overview is, therefore, based upon worst-case scenarios.

Table 4-1 Licence consent planned deposits

Item	Quantity	Comment	Description
HVAC cable	36.5km	Includes contingency of ~0.8km.	Dimensions: 36.5km x 154.7mm Weight: 54.5 kg/m (in air)
Rock bags	756	Includes 100% contingency (378)	Dimensions: 2.4m diameter x 0.6m height (when installed) Weight: 3024 tonnes (4 tonnes per bag)
Concrete mattresses	84 mattresses	For any new crossings and shallow water protection/ stabilisation	Dimensions: 6m x 3m x 0.3m Weight: 735 tonnes (total for all mattresses), 8.75 tonnes each
Grout bags	20	Each bag contains 40x25kg bags	Dimensions: 0.9m x 0.9m x 0.9m Weight: 20 tonnes (1 tonne per bag)
Clump weights	20	May be required where the existing cable is cut to secure the cable ends. Will be made of concrete or will consist of an equivalent weight in chain.	Dimensions: 0.5m high, 1.0m diameter Weight: 300kg
Split Pipe/Cast Iron Shells	2069m		Dimensions: 263mm diameter x 390mm length Weight: 125 tonnes
Uraduct	566m^2	Plastic/synthetic cable protection	
Earthing deposits	4 copper conductors 24 copper rods	Two copper conductors going from the TJP back into the sea – one for the cable and one for the fibre. At the end of these conductors, there will be 12 copper rods up to a maximum of 12m in length installed to a depth of 2m. These quantities would apply at both ends of the cable.	Dimensions (conductors): 4 x 50m length, 95mm^2 cross section (200m length total) Weight (conductors): 8.2 kg/m (164kg weight total) Dimensions (rods): 24 x 2m Weight (rods): 3kg/m (144kg total weight)

Table 4-2 Proposed extent of removals

Item	Quantity	Comment	Description
HVAC cable	5650m	Murkle Inter-tidal up to 300m Rackwick Inter-tidal up to 350m Up to 5000m elsewhere either in one length or a number of discrete lengths.	Cable removal out of inter-tidal areas would only be to facilitate installation of new cable.

4.2 Cable Protection and Stabilisation

As a minimum cable burial will be undertaken at the locations where this was achieved during the 2020 PFE (2) cable installation project. Cable burial in other locations may also be attempted subject to further engineering assessment. Where burial cannot be achieved and it has been identified that there is a need to stabilise and/or protect the cable then other measures may be used, such as concrete mattressing, rock bags, split pipe or uraduct.

Two fibre optic cable crossings will be required along the proposed route. In order to cross the cable, concrete mattresses are proposed to protect both the existing fibre optic cables and the proposed cable. The preference is to utilise the existing crossing points but should this not be possible then up to four concrete mattresses (6m long, 3m wide) per crossing should be allowed for. A typical mattress thickness would be 300mm, so a typical cubed volume per mattress of 5.4m^3.

Further mattresses may be required to cross out of service (OOS) cables and/or provide shallow water cable stabilisation.

Fishing vessels are known to operate in the area and have been assessed as part of the Navigation Risk Assessment (NRA) and Cable Burial Risk Assessment (CBRA). The risk to the cable arises from powered and drifting vessels along the route as well as possible interaction with demersal trawling gear. The main hazard was identified as interaction with static gear during construction. Further information can be found in the NRA.

5. PROJECT DESCRIPTION

5.1 Proposed Route

The assessment of the replacement cable route has been confined to the corridor previously consented for the 2020 cable installation (Marine Licence 07207/20/0) as determined by initial engineering assessments. The detailed design of the new route within this corridor will be informed through inputs from the previous marine survey reports and the ESI.

Within the cable corridor the replacement cable is proposed to utilise the same landing points at both landfalls.

Rock bags are proposed for cable protection and stability, however, the NRA requires that chart datum is not altered by more than 5% without consultation with the MCA. Therefore, where required split pipe or concrete mattresses will be used in the very shallow water due to the lower profile of the structure.

5.1.1 Cable Corridor Selection Process

Table 5-1 Cable corridor selection process stages

Stage	Date	Description
1	19 June 2019	Murkle Bay beach selected as Scottish Mainland primary landing point (LP).
2	14 August 2019	Desktop study identifies preferred survey route as lying between the existing cables. This route was also informed by fisheries considerations (see FLMAP).
3	22 August 2019	Western side of Rackwick Bay selected as Hoy, Orkney primary landing point (LP).
4	9 September 2019	Cable route produced immediately after marine survey completed using preliminary field data
5	7 November 2019	Final cable route produced based on draft survey results, microrouted to improve the approach to Rackwick and Murkle and to maximise boulder avoidance.
6	31 August 2022	Corridor for new Marine Licence application to be the same as previously consented 2019 corridor.

5.1.2 Route Description

One of the main constraints on route design is the maximum lay curvature, or rate of turn, chosen. The lay curvature of a route during installation depends on two factors: the installation method; and the depth of water. All Alter Course (A/Cs) angles are expected to be achievable by a cable ship using standard equipment. The route description below is described from Rackwick Bay to Murkle Bay but the actual direction of installation has not yet been determined.

The survey corridor bathymetry for the existing and proposed cable route is presented below in Figure 5-1.

Figure 5-1 Bathymetry Overview for the Cable Route Corridor from Murkle Bay to Rackwick Bay (MMT 2020)

The Rackwick Transition Joint Pit (TJP) is located at 58°52.2548'N, 003°23.2970'W, at the northern end of Rackwick Bay. A key concern during the routeing of the 2020 Pentland Firth East replacement cable and the present cable proposal has been to avoid crossing if possible the existing live and Out of Service (OoS) Pentland Firth East and West cables, so this landing point (LP) is positioned between them. It lies approximately 300m southeast of Pentland Firth West and 700m northwest of the in-service Pentland Firth East cable.

The beach and the immediate intertidal area of the corridor is characterised by boulders and the cable lay is likely to require additional protection in this area. Once past the inshore area the seabed is expected to transition into sandy sediments. A point at ~13m water depth (WD) depth has been designated as the end of the shore end. The cable lay vessel (CLV) will lay away from this point to the southwest with the geophysical survey data confirming seabed conditions to be relatively even.

The seabed begins to steepen as the corridor exits Rackwick Bay, descending the slope until the seabed flattens out at approximately 75m WD. The offshore slope in this section of the corridor includes a small valley and large, low relief sandwaves. These will be taken into consideration during route planning and avoided where possible.

From here the corridor proceeds southwest, with the 2020 cable currently situated between the two existing cables. The corridor then begins to turn onto a more southerly heading and shortly afterwards enters an area of complex bathymetry which has been assessed as large sandwaves. This area also includes the deepest point along the corridor at 89m WD.

Once the sandwaves have been traversed the corridor travels south for around 3km before entering another patch of sandwaves centred 10km southwest of Hoy. The corridor remains within the sandwave field for approximately 4km. This area was a focus of post-survey route engineering for the 2020 cable due to the nature of the sandwaves, but it is anticipated that the new installation will follow a similar route.

At ~KP17 (approximately halfway along the route) the corridor emerges from the main body of the sandwave field onto seabed of lower relief, although smaller bedforms are still expected to occur along the entirety of the remaining corridor. At ~KP18 the corridor climbs a slope and re-enters the normal transit passage corridor for the Scrabster-Orkney ferry route, which in turn merges with the main shipping channel through the Pentland Firth. The seabed here is relatively flat with water depth averaging around 75m. The corridor then exits the main shipping channel at around KP23.3 and leaves the Scrabster-Orkney ferry route at KP25.6.

At KP27.5 the corridor ascends a large sandbank at the mouth of Dunnet Bay known as “The Sands” with the seabed around this being characterised by the British Geological Society (BGS) as gravelly sand. The Sands caused a notable bump in the 2020 cable route profile between KP27.5 and KP30, where the cable entered Dunnet Bay. To the south of the sandbank the corridor crosses first the Farice then the Northern Lights fibre optic cables, both in service, and also avoids a disused spoil ground lying to the west.

At approximately KP30 the corridor enters Scrabster Harbour Limit. The seabed of Dunnet Bay is relatively flat and shelves toward the LP at less than 3° on average before turning south towards Murkle Bay. The end of the Direct Shore End (DSE) is approximately 740m offshore of the cable LP. This DSE has been permitted by the relatively steep bathymetry of Murkle Bay which allows a typical installation vessel to approach closer inshore.

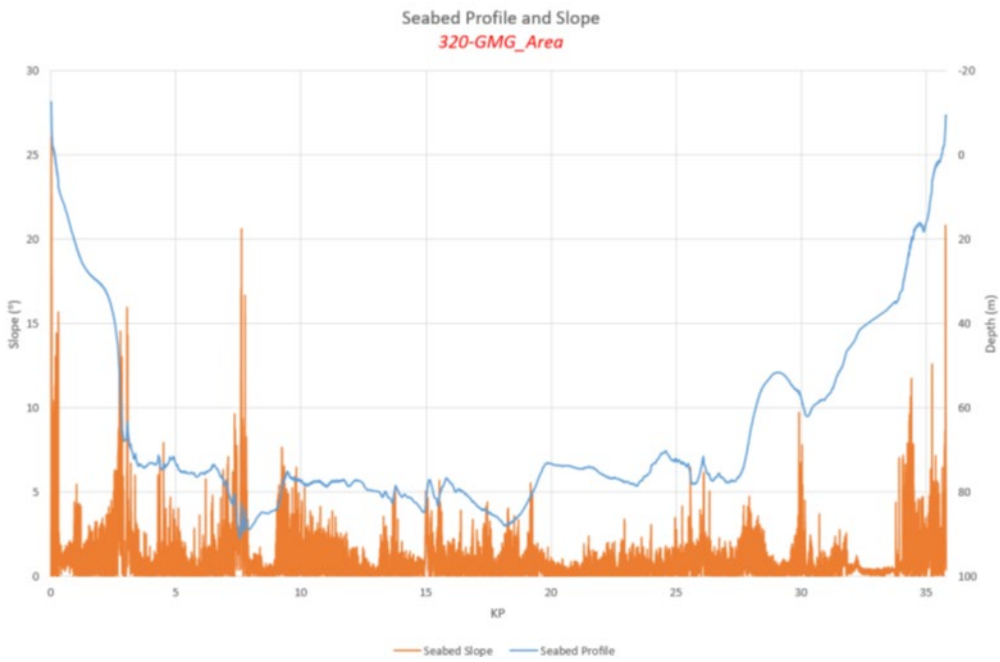
The 17m WD contour has been chosen as the nominal setup position as this should allow even a laden installation vessel to approach to this point with enough room to manoeuvre to avoid running aground. The cable will be floated from the DSE position to the LP between the existing Pentland Firth cables. Some rock outcrops may occur in the bay but overall the corridor is expected to be north of the majority of bedrock. Within the bay the installation will take care to avoid overlying the existing cables, which were accurately located as part of the inshore survey.

The existing Murkle Bay TJP is positioned at 58°36.1790’N, 003°26.0280’W, The new cable will make landfall in proximity to this location.

5.1.3 Route Corridor Profile

The replacement cable route profile shown in Figure 5-2 shows the indicative cable route water depth profile in the upper panel and the slope gradient in degrees, along the route from Rackwick Bay (KP0) to Murkle Bay (KP35) in the lower panel. This information is based on the 2020 cable route.

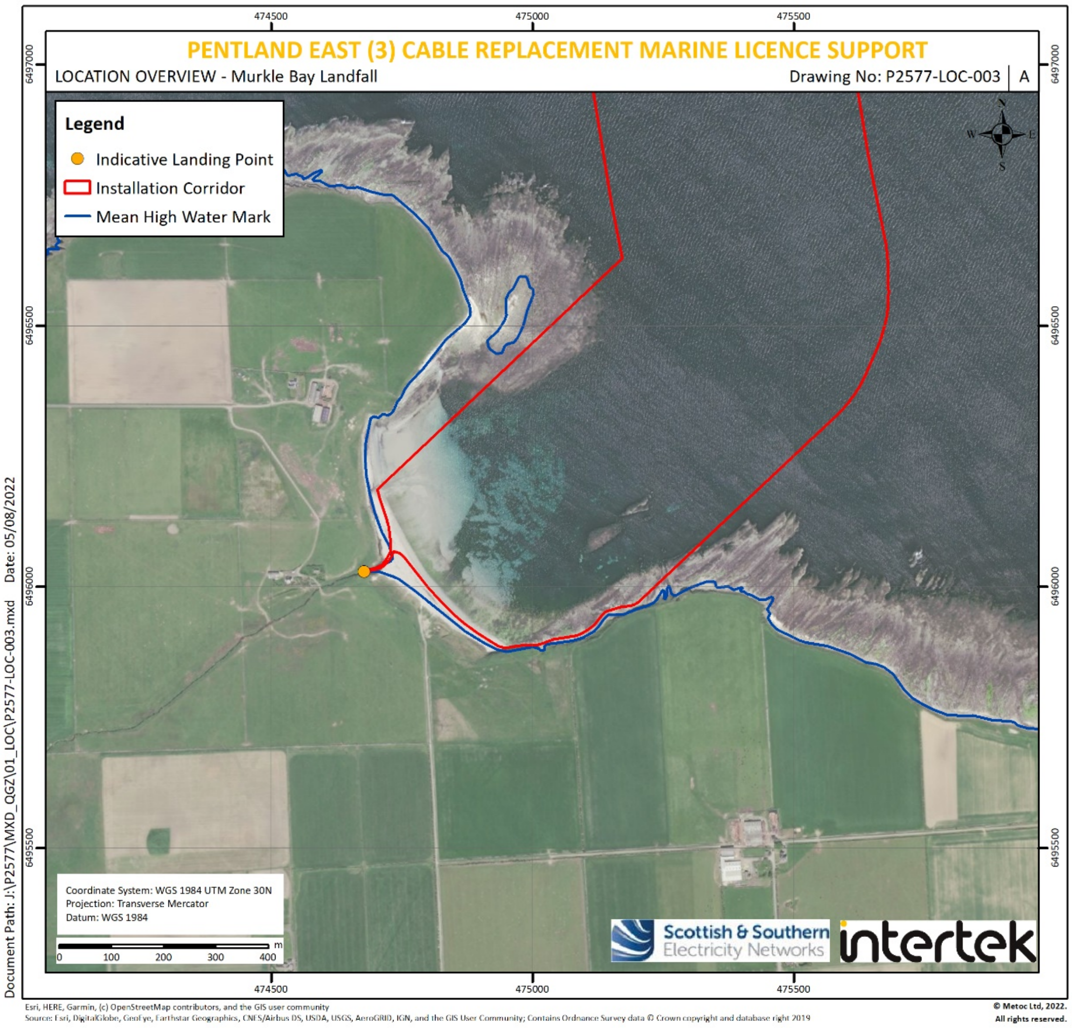
Figure 5-2 Seabed profile and slope along the survey route at 1 m intervals (MMT 2020)



5.1.4 Proposed Murkle Bay Landing Site

An overview of the existing 2020 cable landing point at Murkle Bay, which is also the proposed replacement Pentland East (3) cable landing point, is shown below in Figure 5-3.

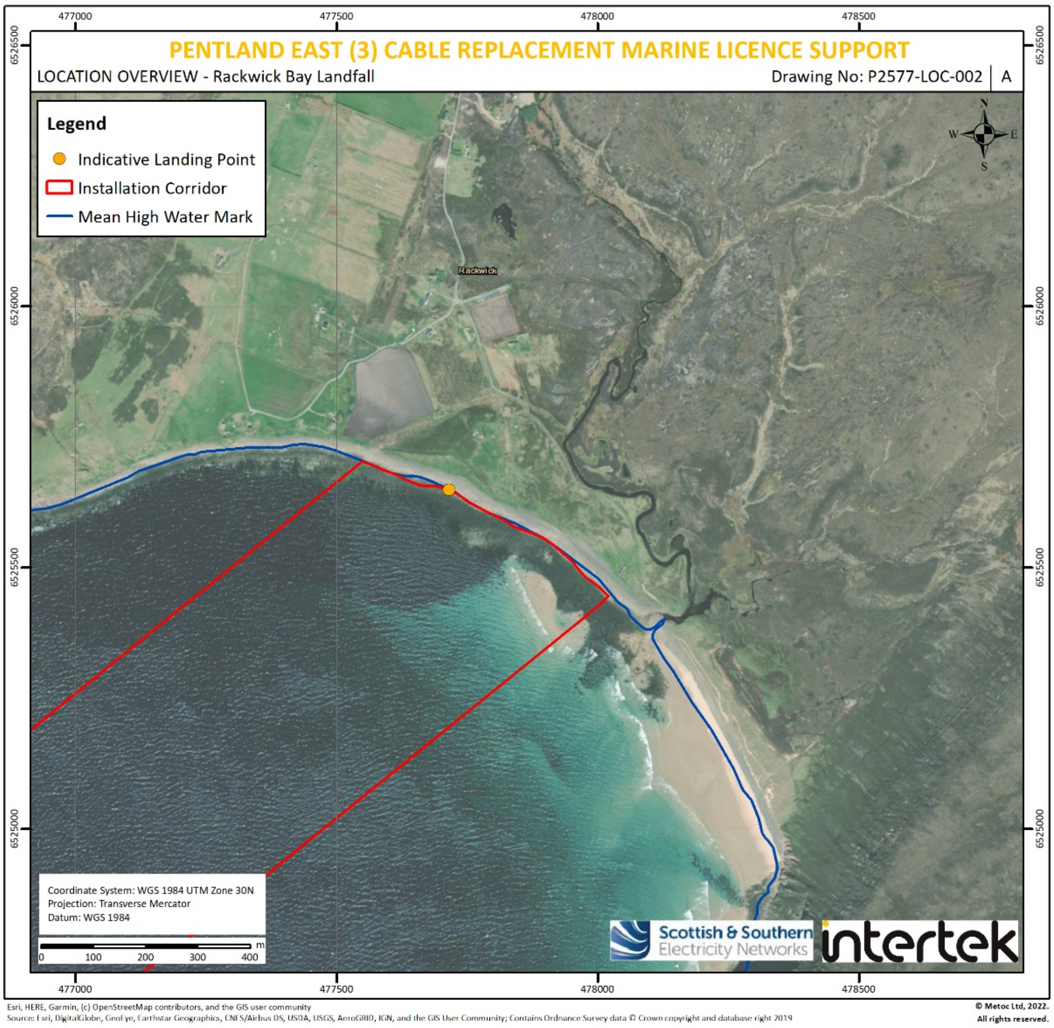
Figure 5-3 Existing landing point at Murkle Bay



5.1.5 Proposed Rackwick Bay Landing Site

An overview of the existing 2020 cable landing point at Rackwick Bay, which is also the proposed replacement Pentland East (3) cable landing point, is shown below in Figure 5-4.

Figure 5-4 Existing landing point at Rackwick Bay



5.2 Proposed Installation Method

An indicative installation methodology is outlined below. The final installation method may vary following the outcome of the CBRA. The indicative methodology is intended to give an overview of the options available to the cable installation contractor. This indicative methodology has been used to inform the environmental assessment provided in ESI, so that the worst-case impact scenarios of the installation have been considered.

5.2.1 Pre-Lay Survey, Boulder-Picking and Out-Of-Service Cable Removal

Prior to lay operations commencing, a further pre-lay survey may be conducted. The objective of the survey would be to:

- Identify and investigate possible debris;

- Identify any obstructions on the proposed route including the presence of boulders which may impede the safe installation of the cable; and
- Identify the location of any in-service fibre optic cables or any OOS cables that cross the proposed route.

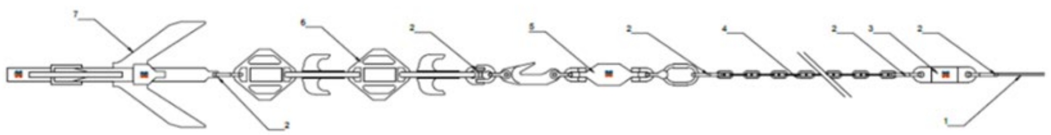
Any obstructions or debris will be removed, if possible. A work class Remotely Operated Vehicle (ROV) or Pre-Lay Grapnel Run (PLGR) will be undertaken to remove debris from the proposed route. In the nearshore area, a diver may be required to remove debris. The 2020 pre-construction survey identified possible OOS cables at Rackwick Bay that needed to be removed for the 2020 installation, further cable removals may be required in this area. There is potential that boulders (usually within +/-5m) of the cable route will be removed using an 'orange peel' grab deployed from a support vessel with suitable crane.

If debris or an obstruction cannot be removed from the planned route, the offshore surveyors will micro-route around the debris/obstruction in consultation with the onboard Client Representative (CR) – at all times staying within the licenced installation corridor.

5.2.2 Pre-Lay Grapnal Run (PLGR)

A PLGR may be required to remove OOS cables and/or to prepare the route for burial where this is deemed appropriate. A typical grapnel train is shown below in Figure 5-5. Multiple PLGR's, both end to end or perpendicular to the route, may be required within the licenced installation corridor to remove OOS cables and as part of pre-burial activity, where appropriate.

Figure 5-5 Typical example of a grapnel train



	ITEM	QUANTITY	SWL	WEIGHT
1	VESSEL WINCH WIRE 48mm x 1000m	1	200TE	-
2	HAMMER LOCK	5	26TE	6Kg
3	BEARING SWIVEL	1	25TE	59Kg
4	Ø32MM CHAIN	Approx 7m	+25TE	-
5	GIFFORD TYPE HOOKS	1	13TE	240.4Kg
6	RENNIE TYPE HOOKS	1	13TE	237.2Kg
7	SLIDING PRONG GRAPNEL	1	13TE	223Kg

5.2.3 Boulder Removing 'Orange Peel Grab' tool

Although the cable route will be engineered to avoid as many boulders as practical, a hydraulic operated grab (Figure 5-6) may be required to remove any boulders that may impede the safe installation of the cable. This system will be operated from the surface and deployed using a support vessel work crane. An ROV will assist in the positioning of this tool.

Figure 5-6 Example of Orange Peel Grab for Boulder Picking

5.3 Landfall Preparation

The landfall areas will be prepared with the following tasks undertaken:

- Site setup, including fencing, signage, welfare units etc;
- Site walk-over;
- Nearshore visual survey;
- Excavation works along landfall cable route from mean low water springs (MLWS) to the Transition Joint Pit (TJB); and
- Cable pull-in preparation, including cable rollers, quadrant winches etc.

Figure 5-7 shows the trench cross-section based on agricultural ground. Any ground not considered agricultural is subject to shallower burial requirements.

Figure 5-7 Indicative trench depth

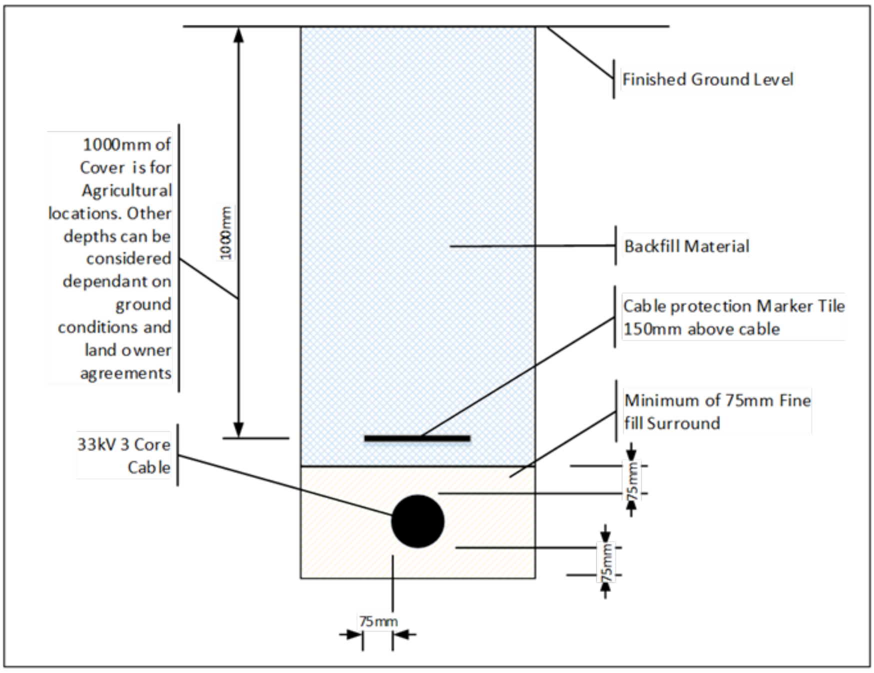


Figure 5-8 and Figure 5-9 show a typical landfall setup with the trench pre-excavated and cable pull in accessories (rollers, diverters etc.) in place ahead of the pull in operations.

Figure 5-10 shows a typical tracked winch that is used for the landfall pull in operations. Both sites (First End and Second End) will be prepared simultaneously.

It is noted that rock breaking between mean high-water springs (MHWS) and MLWS as well as landward of MHWS may be required at both Rackwick and Murkle in order to achieve burial requirements.

Figure 5-8 Excavated trench (Global Marine 2019)

Figure 5-9 Landfall pull in setup (Global Marine 2019)

Figure 5-10 Example of a pull in winch (Global Marine 2019)

5.3.2 Access to Site

Access to the TJP will be via public roads and paths. Where access via public routes is not possible, permissions from landowners have been agreed and will be used throughout the temporary engineering works. All land will be re-instated after completion of the engineering works.

5.3.3 Site Compound

For the onshore engineering works a base will be established which will also act as a local site management office for the works. It shall comprise of, but is not limited to, the following:

- Suitable office accommodation, including space for: site briefing/training, welfare, electrical supply internet and telephone connectivity (where applicable and signal is available);
- Lay-down areas designed to take the biggest loads likely to be delivered to site;
- Secure storage areas for all required materials, with segregation of flammable materials;
- Compound lighting where work is required to be undertaken in low light levels;
- An area designated for waste and waste recycling skips, with clear signs to indicate the waste segregation requirements of each container or skip.

The site shall have a traffic management plan in order to maintain safety of traffic entering and exiting the compound. It should be noted that traffic at the local site compounds shall be light and minimal throughout, with the heaviest traffic during set up and tear down of the compound.

The site compound will be secured from the public by means of Heras fencing where applicable and or pedestrian walkways, all relevant site signage and warning signs will be posted where necessary to ensure site safety and public safety.

All responsible methods will be employed to mitigate environmental damage including spill kits and machine nappy pads to catch leaks and drips on site.

The compound shall comply with the environmental requirements for all activities impacting protected or sensitive habitat or species.

5.3.4 Transition Joint Pit (TJP)

The TJP will be the location where the subsea cable is split out into its individual cores and terminated to a land cable. The TJP is also where the internal fibre optic cable is terminated and the cable armours are clamped and earthed. The TJP at each landfall will be located above MHWS. As the marine licence Application Corridor only covers up MHWS details on the TJP are only included in this report to provide further information on the replacement cable. A TJP plan is show in Figure 5-11 and an example layout is shown in Figure 5-12.

Figure 5-11 TJP Plan (SSEN 2021)

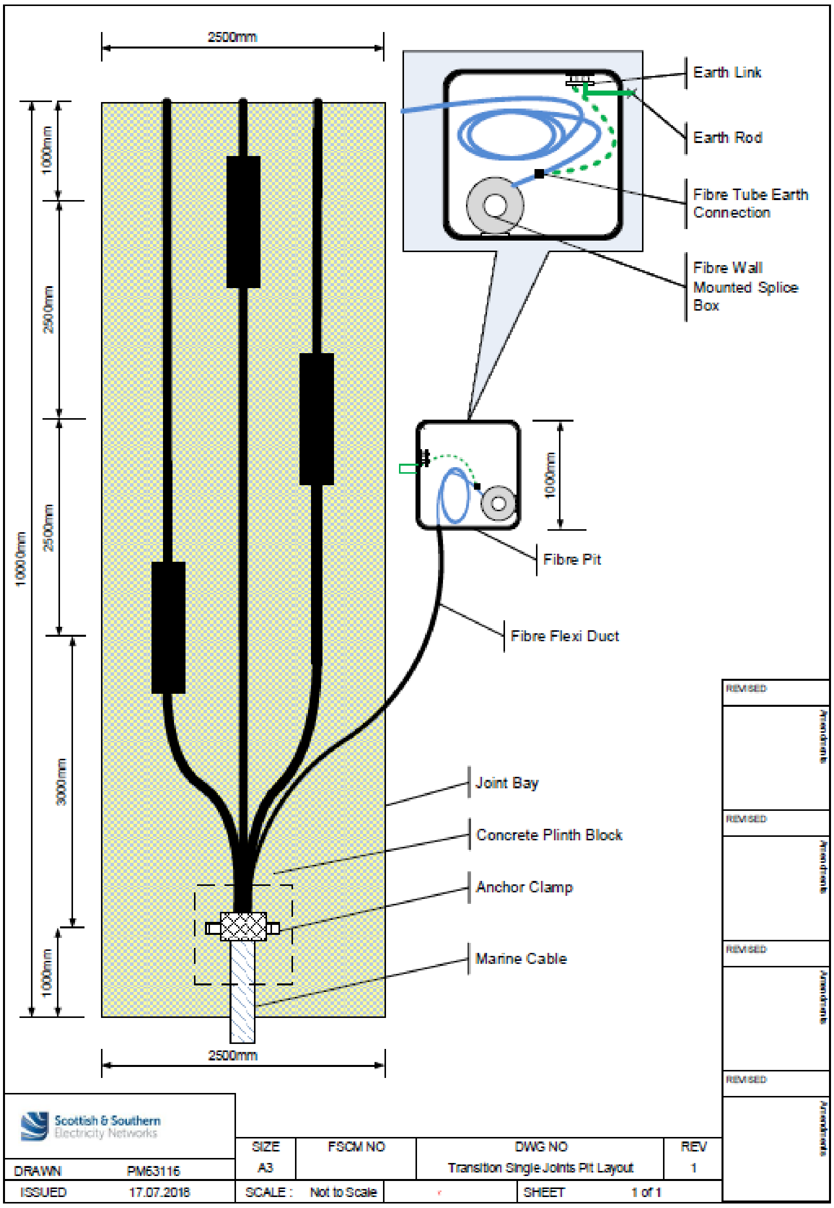


Figure 5-12 Example of a TJP final layout (SSEN 2019)

5.4 Marine Cable Installation

The following installation method is based on that utilised during the 2020 installation and has been used as the basis for the present environmental assessment.

5.4.1 First End Pull-In

The CLV will position at the first end pull-in site, generally stationed at the 10m WD contour (this is dependent on the vessel's draft), and deck handling equipment will be used to direct the cable to the over-boarding chute.

A small support craft will then retrieve the pull-in winch wire from the shore and return it to the CLV where it will be connected to the cable end. The shore end winch will commence pulling in the cable with buoyancy units attached onto the cable as it leaves the vessel in order to 'float' the cable ashore. Several additional small craft may be used to support the activities, including bringing the first end of the cable ashore and also in removing the buoyancy units.

Figure 5-13 shows typical first end pull-in operations.

Figure 5-13 First end pull in (Global Marine 2019)

5.4.2 Cable Lay Operations

Once the cable is successfully pulled to its required position onshore, surface swimmers will gradually remove the buoyancy units allowing the cable to come to rest on the seafloor.

Once all buoyancy units have been removed, the CLV will commence laying the cable on the seabed from the First end to the Second end. The CLV will be a DP2 Class vessel and expected cable laying speed will be between 200m/h and 450m/h.

During cable lay operations, the vessel crew will monitor the lay to ensure the cable is laid within the consented installation corridor and that the mechanical parameters of the cable are adhered to; expected lay tensions are between 10kN and 20kN.

Monitoring of the cable's touchdown point on the seabed, which is expected to be between 1 x WD and 1.5 x WD away from the installation vessel, will be conducted with the vessel's ROV and/or subsea sonar equipment.

During cable lay operations, the vessel will install the cable within the cable installation corridor. During these operations, the vessel structure may be outside the licenced corridor however all deposits will be installed within the allocated boundary. Vessel movements will be notified by notice to mariners issued to inform other sea users for safety as outlined in the supporting Fisheries Liaison Mitigation Action Plan (FLMAP).

5.4.3 Second End Pull-In

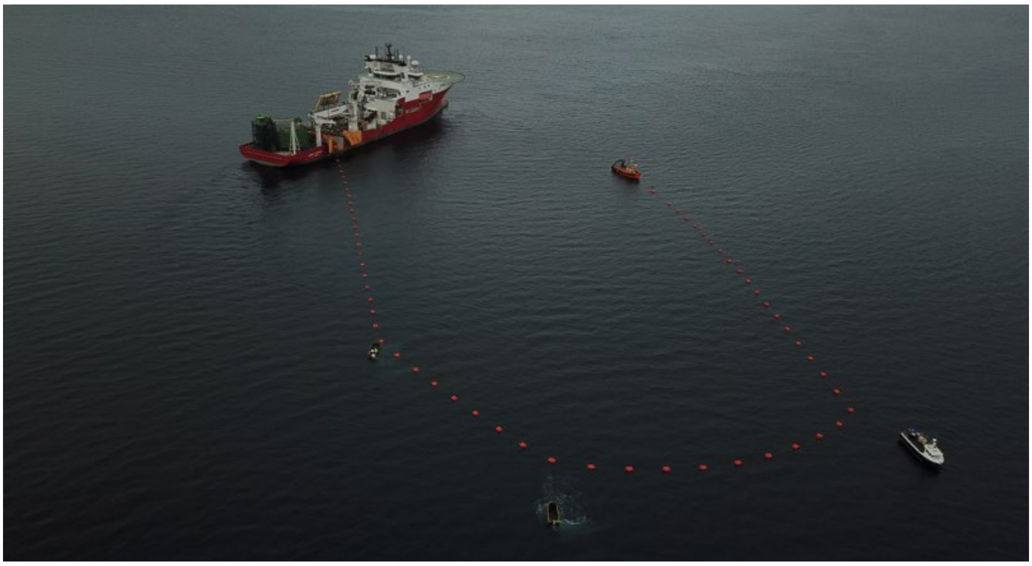
Once the cable is laid across the seabed, the vessel will either manoeuvre off the RPL and float the cable off the vessel or remain in position on the RPL and pay out the cable into a floated omega bight. This will allow the cable to be cut at the required length prior to pulling the cable into the second end landing point.

As for the First end, buoyancy units will be attached to the cable as it is being paid out to float the cable ashore. An example of a second end bight is shown in Figure 5-14.

Once the cable is floated out into a bight, support craft will retrieve the pull-in wire from the shore end winch and attached it to the cable end. The cable will then be pulled into the second end landing point with surface swimmers gradually removing the buoyancy units allowing the cable to come to rest on the sea floor. As with the first end pull-in, several additional small craft may be used to support the activities including bringing the second end of the cable ashore and also in removing the buoyancy units.

The bight may be outside of the cable installation corridor whilst in the water column at certain points during deployment, however final installed position will be within the boundary of the licenced area. The supporting FLMAP and ESI references the notifications issued to sea users to inform which activities are taking place. Navigational broadcasts will be issued via Navigational telex (NAVTEX) and Notices to Mariners (NTMs) distributed by the Kingfisher fortnightly bulletin and on social media.

Figure 5-14 Second end omega bight (Global Marine 2019)



5.4.4 Earthing Operations

5.4.4.1 LP 1 – Rackwick Bay

Up to two trenches will be excavated (depth between 600mm and 750mm) from the TJP towards the sea. Inside each trench, a copper conductor will be run from one side of the trench to the other. The copper conductor will pass MLWS. Depending on the soil resistivity in the area, the copper conductor could be up to 50m in length. A total number of 12 earthing rods may be used to further improve the earthing system to reach the required value. Once this value has been achieved, a clump weight will be fitted to the end of the conductor. All trenches will be covered with a layer of fine material and then filled with the excavated soil up to the mean ground level.

5.4.4.2 LP 2 – Murkle Bay

Up to two trenches will be excavated (depth between 600mm and 750mm) from the TJP to MLWS towards the sea. Inside each trench, a copper conductor will be run from one side of the trench to the other. At the MLWS end of the trench, another pit will be excavated with multiple rods being driven into the pit. Depending on the soil resistivity in the area, the copper conductor could be up to 50m in length. A total number of 12 earthing rods may be used to further improve the earthing system to reach the required value.

The copper conductor will be connected to the rods array at the MLWS side and/or at the TJP earth hub. The copper conductor will pass MLWS, with the final length required dictated by the earthing measurement defined by the cable manufacturer. Once this value has been achieved, a clump weight will be fitted to the end of the conductor. All trenches and pits will be covered with a layer of fine material and then filled with the excavated soil up to the mean ground level.

5.5 Cable Protection Methods

This section outlines the envelope of all potential marine cable stabilisation and protection methods for which consent is being sought.

The following methods were all identified for the installation of the replacement PFE cable in 2020. The minimum extent of burial that will be undertaken is that achieved in the 2020 installation campaign although burial in other locations may be attempted. Other methods detailed below will be utilised in non-burial areas where additional cable protection or stabilisation is required.

5.5.1 Mattress Installation

Two fibre optic cable crossings will be required along the proposed route. In order to cross the fibre optic cable, concrete mattresses are proposed to protect both the existing cable and the proposed cable. Where possible the existing crossing locations and mattresses will be utilised.

Up to four concrete mattresses (6m long, 3m wide) per crossing should be allowed for with a typical volume per mattress of 5.4 m^3.

Further mattresses may be required to cross OOS cables along the route. This may be considered a more economical solution than PLGR described in Section 5.2.2.

Figure 5-15 Concrete mattress on deck

5.5.2 Rock Bag Installation

The cable protection strategy may include the installation of rock bags onto the cable to provide stability. The rock bags are stored on the vessel and lifted into position using the vessel's crane. The vessel's ROV monitors the installation and detaches the crane wire from the rock bag once in position. This is shown in Figure 5-16.

Where practicable, the rock bags will be filled with stone local to the installation site. The rock bags may be installed as soon as the cable is laid using a separate vessel. Simultaneous Operations (SIMOPS) between the two vessels will be managed in the planning and offshore phase via implementation of a SIMOPS plan. Each vessel will be named in the NtM as required in the FLMAP. The previously consented value for rock bag installation was up to 1375 x 4 Te rock bags, however the quantity installed was significantly less. The quantity for which consent is being sought for this application is based on the previously installed figure (378) with additional 100% contingency to allow for any additional requirements following completion of detailed design studies including the On Bottom Stability Analysis.

Figure 5-16 Rock bags on deck

5.5.3 Grout Bag Installation

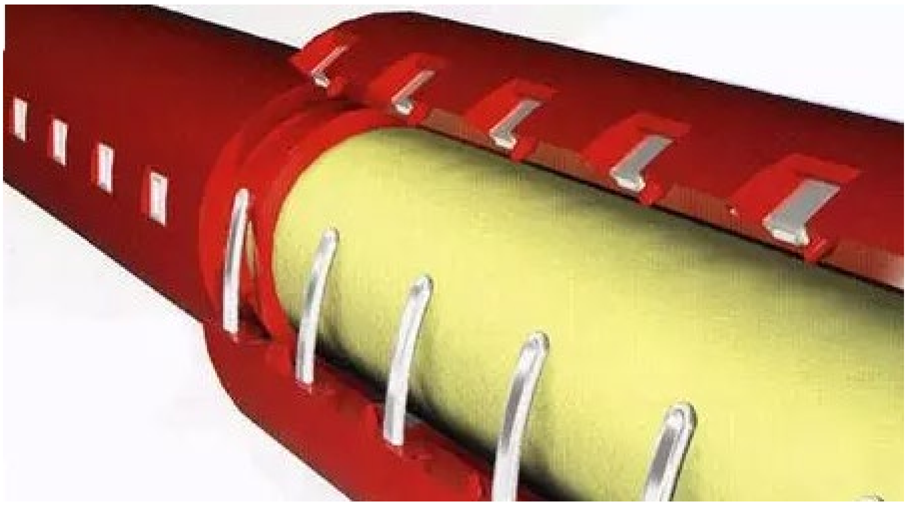
There are currently no pre-installation plans for grout bags to be used, however they may be required to rectify any cable free spans that are observed following cable installation. If these are required, then they can be installed in a similar manner to the rock bags as described in Section 5.4.6 above. Each 1 Te grout bag (0.9m x 0.9m x 0.9m) contains 40 x 25kg individual units. If required, divers will position the individual bags where free span rectification is required.

5.5.4 Split Pipe or Uraduct Installation

The cable protection strategy may include the installation of split pipe or Uraduct. Generally, this is installed following the cable pull in operations by divers or from the CLV, or through a combination of both methods. This is typically used to protect the cable in the nearshore and intertidal areas and where rocky reef sections are encountered.

An example of Uraduct is shown in Figure 5-17.

Figure 5-17 Example Uraduct installation (Uraduct 2019)



5.6 Post-Lay Trenching

The cable protection strategy includes the post lay burial of the cable, this uses a subsea trencher which is launched off the trenching support vessel, landing astride the cable. Once in position the trencher will bury the cable either with high pressure water jets (jetting tool) or a mechanical chain cutter (cutting tool), or a combination of both (hybrid tool). Table 5-2 provides an overview of example burial tool specifications. The choice of tool will depend on the soil type in the area.

Table 5-2 Burial Tool Overview

Mode	Max Footprint (width) (m)	Length (m)	Weight in Air (Te)	Capability
Jetting	9.0	12.5	45	Soil Strength up to 125 kPa
Cutting / Hybrid	9.0	12.5	45	Soil Strength up to 400 kPa
Mass Flow Excavator	1.9	1.9	4.5	Burial in areas of steep slopes

5.7 As-Built Survey and Site Reinstatement

Following completion of operations, an as-built survey will be undertaken of the replacement cable and protection. This will record the as installed position of the cable and the deposits used to stabilise and or protect the cable. The landfall sites will also be re-instated as agreed with landowners.

The replacement cable will subsequently be electrically jointed to the land HV infrastructure. The routing and installation of the land HV infrastructure is not covered as part of this Project Description which supports the marine licence application.

The as-built survey will document the installed position of the cable from TJP to TJP with events listed and positions given (i.e., rock bags, mattresses, articulated pipe etc.).

There is a possibility of an interim survey taking place to confirm the position of the cable if the cable laying vessel is not involved in the trenching of the laid cable. This interim survey will take place after the cable has been laid and before the arrival of the trenching vessel. If the same vessel is used for both activities, then this survey will not be required.

5.8 Decommissioning

5.8.1 Intertidal Removal of OOS Cable

The intertidal sections of OOS cable will be removed at both landfall locations. The maximum extent of cable removal in the inter-tidal zone is estimated to be up to 300m at Murkle Bay and up to 350m at Rackwick Bay. The marine and land cable sections will be identified and marked with flags or other suitable marker down to MLWS.

An excavator will be used to remove the soil covering the cable, until the cable is fully exposed. The section of cable in the intertidal area will be accessed during low tide. Once the cable is exposed, the cut location will be agreed, and the cable cut with the aid of a suitable cutting tool. These tools will also then be used to cut the cable into short sections so that it can be removed from the trench. The cut sections of cable will be bundled together for ease of handling and they can be moved into temporary storage and later removed from site.

A Waste Transfer Note (WTN) will be raised to remove materials from site and they will be disposed of according to the regulations set out by the Scottish Environment Protection Agency (SEPA) in accordance with the Waste Management Licensing (Scotland) Regulations 2011. Cast iron pipe sections will be either secured to the cable or removed and stored separately, always ensuring they do not constitute a hazard for the workforce or environment during handling and storage of cable sections. All cable removal operations would precede the activities relating to installation of the new cable. The old trench profile may be used to facilitate the new cable installation following an onsite assessment.

5.8.2 Offshore Removal of OOS Cable

In the event that removal of a larger section is required the operations and equipment required will be as follows:

- Cable Handling System
- Work Class ROV
- Subsea Crane / A-Frame
- Survey Spread
- Cable De-Burial / Burial Spread

As discussed in the decommissioning plan (Document Reference P2577_R5827), the cable can be de-buried using either similar techniques to installation to uncover the cable from the seabed, or via simply pulling the cable with sufficient force if the seabed consists of soft soil (Smith, Garrett and Gibberd, 2015). Various methods may be required to loosen the cable from the seabed. One of the methods uses “under runs”, which consists of a device to be installed under the cable while being towed with a line from a vessel (BERR, 2008). This method is only applicable to shallow burial depths (less than 1 m) and soft soils using a vessel equipped with suitable cable recovery equipment. The sediment above the cable can be removed using a mass flow excavator (MFE) to ensure the cable can be exposed for easy retrieval. Where appropriate, recovery works are monitored with the aid of a remote operated vehicle (ROV), and the cable either reeled or cut up in sections and stored on the vessels deck. The cable can be cut at the 3rd party asset crossing locations and at the extents of external cable protection, where this has been used, if the intention is to leave the external cable protection in-situ.

The anticipated maximum footprint of the removal activities will be 7m in width and the zone of disturbance for the trenching activities for changes in suspended solids has been calculated as 300m (as discussed in the ESI (Document Reference P2577_R437)).

Regardless of the de-burial method, the cable end is attached to the retrieval vessel where they are spooled onto a drum or cut into lengths using a hydraulic cutting tool on board the vessel if the cable is not planned to be used afterwards (Smith et al., 2015; Topham and McMillan, 2017). Therefore, the cable decommissioning vessel needs to be equipped with the necessary tools to lift, cut and stow the cable and operate the de-burial vehicle with the possibility to use the same cable installation vessel (Smith et al., 2015).

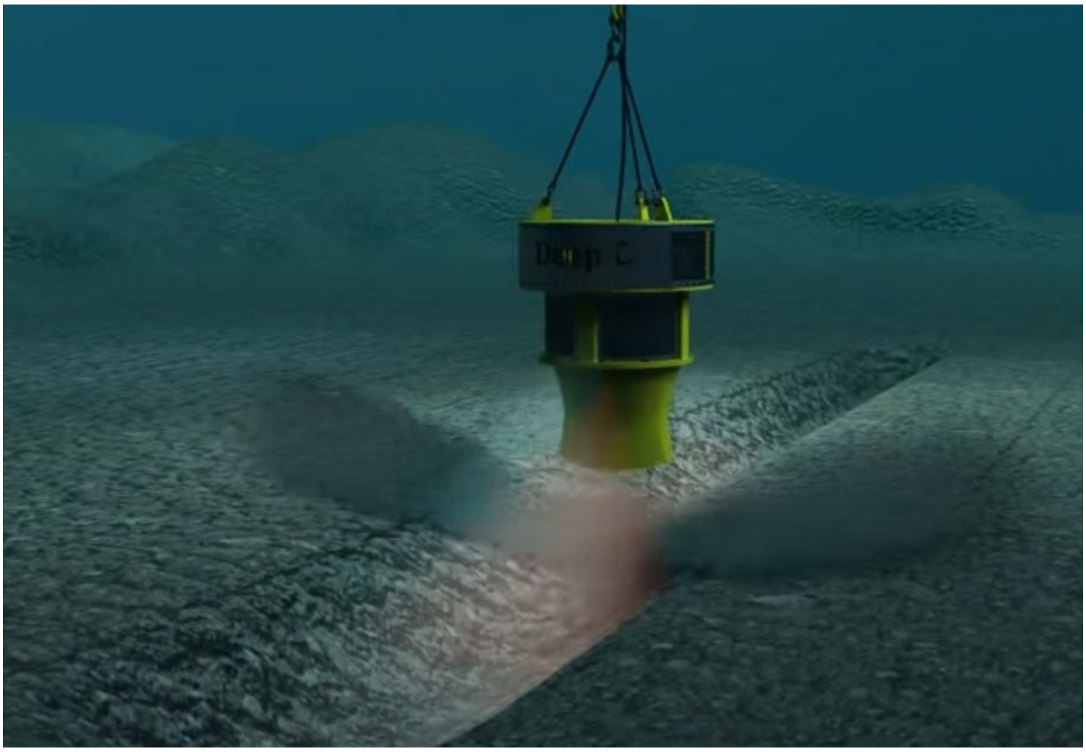
Allowance has been made for up to 5000m of cable to be removed below MLWS in order to facilitate installation of the new cable. The final requirements for any removals in this zone will be determined by final engineering studies. Any removal may be in several discrete lengths at various locations or a single continuous length depending on the engineering requirements.

5.8.3 Removal via Mass Flow Excavator (MFE) and/or Controlled Flow Excavation (CFE)

The use of a MFE and/or CFE may be required during recovery of sections of the faulted Pentland Firth East (2) cable. A typical MFE unit is shown in Figure 5-18.

Once the cable is de-buried, a visual inspection of the cable is to be undertaken by an ROV. The cable will be cut subsea with an ROV mounted tool, or a dedicated cut & grab tool. Once the cable is cut, the section to be removed is recovered to deck. Where the cable has been buried the cut ends will be secured with clump weights and the ends re-buried as far as is reasonably practicable. Where cable sections have been removed that were surface laid the cut ends will be secured with clump weights, rock bags or concrete mattresses.

Figure 5-18 Typical MFE unit (Deep C 2015)



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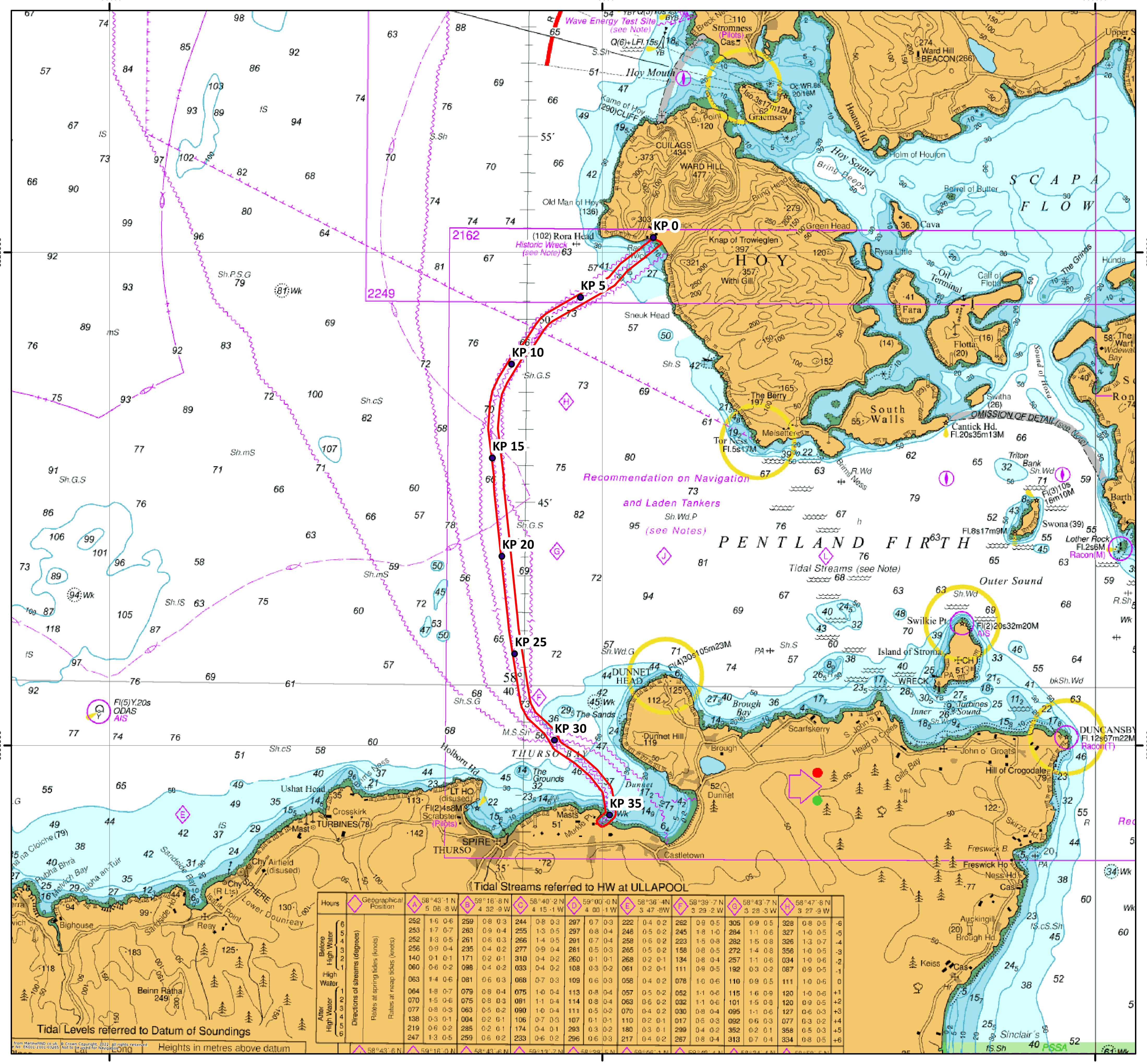
3 Topham, Eva & Mcmillan, David. (2016). Sustainable Decommissioning of an Offshore Wind Farm. Renewable Energy. 102. 10.1016/j.renene.2016.10.066.

APPENDIX A

Route Overview Chart



PENTLAND FIRTH EAST (3) CABLE REPLACEMENT

LOCATION OVERVIEW

Cable Route Corridor

Drawing No: P2577-LOC-004	A

Legend

- KP
- Installation Corridor

NOTE: Not to be used for Navigation

Date	18 November 2022
Coordinate System	WGS 1984 UTM Zone 30N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	MarineFind; ESRI; SSE
File Reference	J:\P2577\MXD_QGZ\01_LOC\P2577-LOC-004.mxd
Created By	Alice Gymer
Reviewed By	Irinios Yiannoukos
Approved By	Andrew Page

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