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Marine License _Shetland HVDC Link - Construction Method Statement

LT000009 - Shetland HVDC Link

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Marine License _Shetland HVDC Link - Construction Method Statement

Shetland HVDC Link

Table of Contents

List of Figures

List of Tables

List of Terms and Abbreviations

Term	Definition
SHE Transmission	Scottish Hydro Electric Transmissions plc
NKT	NKT HV Cables AB
AHC	Automatic Heave Compensation
AR	Assist and Recovery
BAS	Burial Assessment Study
BSF	Below Sea Floor
CBPP	Cable Burial Protection Plan
CBRA	Cable Burial Risk Assessment
CCTV	Closed Circuit Television
CLV	Cable Lay Vessel
CPS	Cable Protection System
CPT	Core Penetration Testing
CPTU	Core Penetration Testing Unit
DGPS	Differential Global Positioning System
DOC	Depth of Cover
DOL	Depth of Lowering
DP	Dynamic Positioning
DPR	Daily Progress Report
DTM	Digital Terrain Model

Term	Definition
DVL	Doppler Velocity Log
EPS	European Protected Species
FO	Fibre Optic
FOC	Fibre Optic Cable
GNSS	Global Navigation Satellite Systems
GRP	Glassfiber Reinforced Plastics
GPS	Global Positioning System
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HDD	Horizontal Directional Drill
HDPE	High Density Polyurethane
HIRA	Hazard Identification and Risk Assessment
HLS	Horizontal Lay System
HMB	Horse Mussel Bed
HPU	Hydraulic Power Unit
HSEQ	Health Safety Environment and Quality
HVAC	High Voltage Alternate Current
HVDC	High Voltage Direct Current
FLO	Fishing Liaison Officer
INS	Inertial Navigation System

Term	Definition
KHz	Kilohertz
KP	Kilometre Point
Kn	Knots
LARS	Launch and Recovery System
LAT	Lowest Astronomical Tide
MBES	Multibeam Echo Sounder
MBR	Minimum Bending Radius
NCMPA	Native Conservation Marine Protected Area
OCM	Offshore Construction Manager
OM	Operation Manager
OOS	Out of Service
OSV	Offshore Survey Vessel
PIM	Project Installation Manager
PE	Polyurethane
PLGR	Pre-Lay Grapnel Run
RAO	Response Amplitude Operator
ROTV	Remotely Operated Towed Vehicle
RPS	Route Position List
ROV	Remote Operated Vehicle
Hs	Significant wave height

Term	Definition
SBP	Sub-Bottom Profiler
SBI	Sub-Bottom Imager
SIT	Site Item Test
SOW	Scope of Work
SS	Shift Supervisor
SSS	Side Scan Sonar
TBC	To Be Confirmed
TDM	Touch Down Monitoring
TDOB	Target Depth of Burial
TDP	Touch Down Point
TJB	Transition Join Bay
TSV	Trenching Support Vessel
QC	Quality Check
USBL	Ultra-Short Baseline System
UXO	Unexploded Ordnance
VC	Vibrocore
WROV	Work Class Remote Operated Vehicle
Tp	Wave peak points

Table of References

Reference	Document No	Revision	Document Title
[1]	A-200409-S00-REPT-003	A02	Shetland HVDC Link Environmental Appraisal
[2]	07203/20/0	03/07/2020	MARINE (SCOTLAND) ACT 2010, PART 4 MARINE LICENSING
[3]	07357/20/0	03/07/2020	THE MARINE AND COASTAL ACCESS ACT 2009, PART 4 MARINE LICENSING
[4]	2020/11/WL	26/07/2020	Works Licence Application
[5]	1AA0428959	A	Vessel Management Plan – SIMOPS Communication
[6]	1AA0428474	C	Shetland CBPP Overview Chart (Appendix A)
[7]	1AA0295404	A	Cable Burial Protection Plan
[8]	1AA0395444	A	Construction Environmental Management Plan (Marine CEMP)
[9]	1AA0400404	A	Marine Archaeological Finds Plan
[10]	1AA0400423	A	Marine Mammal Protection Plan
[11]	1AA0400439	A	Marine Non-Native Species Plan
[12]	1AA0403687	A	Marine Emergency Spill Response Plan and SOPEP
[13]	A-200409-S04-TECH-003		LT09 Shetland HVDC Link Communications Plan (Xodus, 2021)
[14]	A-200409-S04-TECH-004		LT09 Shetland HVDC Link Inspection, Repair and Maintenance Plan (Xodus, 2021)
[15]	A-200409-S04-TECH-005		LT09 Shetland HVDC Link Fisheries Liaison Mitigation Action Plan (Xodus, 20201)
[16]	A-200409-S04-TECH-006		LT09 Shetland HVDC Link Marine Archaeological Written Scheme of Investigation (ORCA, 2020)
[17]	A-200396-S00-TECH-001-A01		Shetland HVDC Project Burial and Protection Summary

1 Introduction

This Construction Method Statement for offshore works is provided to the authorities to comply with the conditions stated in Part 4 of the Marine (Scotland) Act 2010, and Part 4 of the Marine and Coastal Access Act 2009 with regards to the application made by Scottish Hydro Electric Transmission plc for the Marine License for the Shetland HVDC Link.

This document describes the planned installation methodology, as described in the Shetland HVDC Link Marine Environmental Appraisal, Ref [1], submitted with the Marine Licence application for the installation of a single circuit High Voltage Direct Current (HVDC) link, between Weisdale Voe in Shetland and Noss Head in Caithness.

2 Project Overview

Shetland is not presently connected to the UK mainland electricity Transmission grid and as such is solely reliant on island-based generation, this generation is in the majority derived from fossil fuels with the support of onshore wind.

There is currently approximately 600MW of consented renewable energy generation on the Shetland Isles, which will require connection to the UK mainland transmission network once these projects are constructed. Scottish Hydro Electric Transmission Plc (SHE Transmission) is the licenced Transmission Owner in the north of Scotland, and as such, has a requirement to provide connection to the UK's network when requested by a generator.

In order to meet the dual requirement of the provision of reliable transmission level supply and export surplus renewable generation, SHE Transmission are planning to install a single circuit 253km long, 600MW High Voltage Direct Current (HVDC) link between Weisdale Voe in Shetland and Noss Head in Caithness ('Shetland HVDC Link' or 'the Project'). The marine cable infrastructure will consist of a single bundle comprising two conductor cables and one fibre optic communications cable, to allow control of the substation and HVDC converter station. Marine cable solution provider, NKT, will be responsible for the manufacture and installation of the subsea cable.

An overview of the marine installation corridor is provided in Figure 2-1.

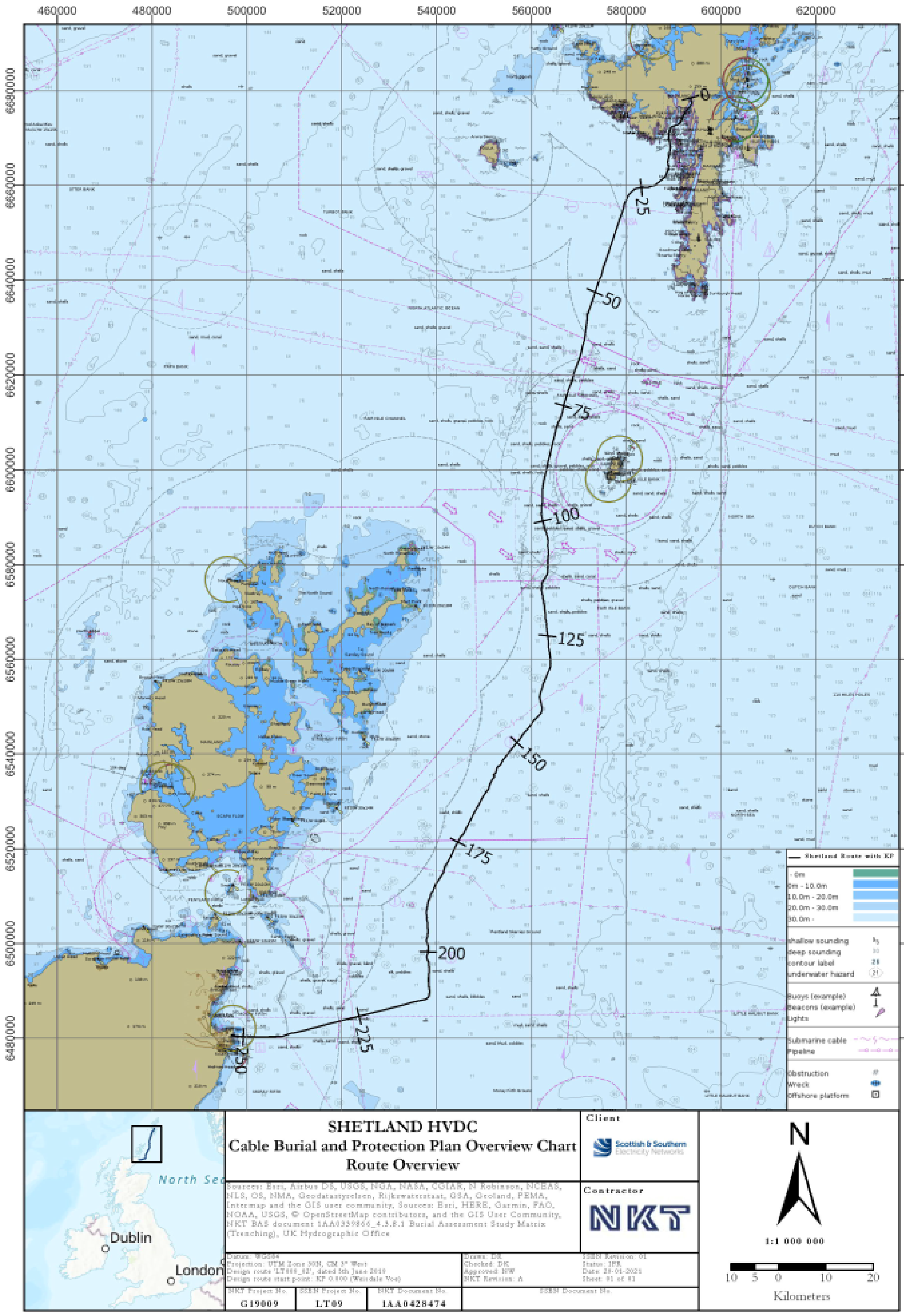


Figure 2-1:Shetland HVDC Link Route Overview

3 Document Purpose

This Construction Method Statement relating to the submarine cable installation and protection works to be carried out by NKT HV Cables as part of the Shetland HVDC Link.

This document shall describe the planned cable installation construction and protection works for the cable route from Shetland landfall at Weidale Voe to Noss Head landfall at Caithness.

This document is to be submitted to Marine Scotland and to Shetland Islands Council respectively to discharge conditions granted for the installation of a High Voltage Direct Current (HVDC) cable link for the subsea cable route across the sea floor under:

- Marine Licenses, issued under the Marine (Scotland) Act 2010 (ML 07203) and the Marine and Coastal Access Act, 2009 (ML 07357); and
- Condition [2] of the Marine Works Licence [ref: 2020/011/WL #] issued under the Zetland County Council Act, 1974.

Location of works inside and outside the 12NM boundary is shown in Figure 2-1.

This document describes the elements within the scope of the Construction Method Statement for the marine works and Marine Licence conditions:

- Installation and protection of the HVDC Link submarine cable bundle between the landfall of Weisdale Voe, Shetland and the landfall at Noss Head, near Wick as shown in Table 3-1.

3.1 Overview

The Project involves laying of two HVDC submarine cables bundled with a fibre optic cable which are held together with a bundling yarn. The cable shall be installed within the consenting corridor of the Marine Licence in three (3) separate laying and protection campaigns in 2022 and 2023, refer to schedule of planned works in Section 3.5. The cable shall be pulled in to each of the landfalls and then laid away along the cable route and wet stored, then the third campaign completes the cable sections laying the centre section and jointing the cables to the previous laid and wet stored cable ends, each section of cable shall be then protected by means of either:

- Horizontal Directional Drilling – Steel ducts pushed out from shore (Noss Head)
- Polyurethane (PE) Ducts installed in to an excavated trench and backfilled (Weisdale Voe)
- Cable burial by post lay trenching;
  - or where seabed conditions or crossed assets prevent the required depth of lowering the cable shall be protected by means of;
- Cable protection systems – Uraduct (or similar), Cast-Iron Shells or Bending Restrictors

- Cable Crossing protection with either pre-installed Concrete Mattresses, and/or pre-lay and post-lay rock berm: or
- Post lay rock protection where cable depth of lowing has not been achieved.

Details of the each of the marine construction methods can be found further within this document and in the Cable Burial Protection Plan, document Ref, [7].

The marine consenting corridor runs in a south westerly direction from Weisdale Voe in Shetland for 210km before turning westerly to Noss Head, near Wick, Caithness. The installation corridor is 200m in width, and has been selected in consideration of technical and environmental constraints as described in the project environmental appraisal and supporting site information, with reference to the Marine Environmental Appraisal (MEA) Ref [1]:

- Existing infrastructure including pipelines and telecom cables
- Seabed bathymetry
- Seabed geology and sediment characteristics for cable burial confidence
- Commercial marine traffic and fishing
- Cultural heritage and marine archaeology
- Benthic ecology and habitat types
- Sites of marine protected habitats

The installation corridor is not a straight route and varies to avoid these features, NKT shall conduct a further pre-lay and UXO survey to optimise the route for cable installation and protection, by further micro route engineering.

3.2 Hierarchy of Documents

The hierarchy of documents shown below reflects how NKT incorporate the Marine Authority Permit conditions and SHE Transmission environmental assessments and communication plans into our own operating procedures for the marine construction works. All documents shown shall be provided to the offshore contractors and managed by NKT and SHE Transmission's Offshore Representatives.

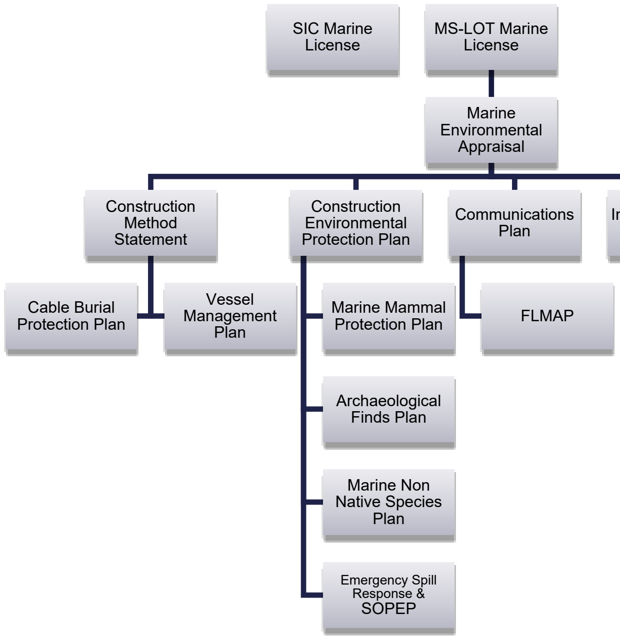


Figure 3-1: Hierarchy of Documents

3.3 Control & Management of Marine License Conditions

All offshore works contractors shall be provided with the Marine Licenses, Contract Works Information and Site Information, NKT Contract Works Information and Health, Safety & Environmental Plans, as detailed in the hierarchy of documents shown in Figure 3-1.

3.4 Reference to License Conditions

Table 3-1 below details the marine consents permit conditions and how they are addressed, with more detail on the structure of the document provided in Table 3-2.

Table 3-1: Relevant license conditions

Relevant Licence Condition	Relevance to this CMS
Marine (Scotland) Part 4, Marine License for Territorial Waters inside 12nm 07203/20/0 (7.) In the event of the licensee becoming aware that any of the information on which issue of the license was based has changed the licensing authority must be immediately notified of the details. (10.) The licensee must ensure that no deviation from the schedule specified in the license is made without the further written approval of the licensing authority. (20.) The licensee must submit a Cable Burial and Protection Plan (CBPP) to the licensing authority for their written approval no later than two months prior to the commencement of operations relating to the	Addressed through provision of this document and associated plans *(7) (1AA0392078 Construction Method Statement & 1AA0295404 Cable Burial Protection Plan)* *(10) (1AA0392078 Construction Method Statement & 1AA0295404 Cable Burial Protection Plan)* *(20) (1AA0295404 Cable Burial Protection Plan)*

license. It is not permissible for operations relating to the licence to commence prior to granting of such approval. In granting such approval, the licensing authority may consult any such other advisors, organisations or stakeholders as may be required at their discretion. The CBPP must be consistent with the marine license application and supporting information. All works must proceed in accordance with the approved CBPP. The CBPP must include the following: a) Details of the location of all works relating to the license and cable laying techniques:	*(20.a) (1AA0295404 Cable Burial Protection Plan)*
Marine (Scotland) Part 4, Marine License for Offshore Waters outwidth 12nm 07257/20/0 (6.) In the event of the licensee becoming aware that any of the information on which issue of the license was based has changed the licensing authority must be immediately notified of the details. (9.) The licensee must ensure that no deviation from the schedule specified in the license is made without the further written approval of the licensing authority. (19.) The licensee must submit a Cable Burial and Protection Plan (CBPP) to the licensing authority for their written approval no later than two months prior to the commencement of operations relating to the license. It is not permissible for operations relating to the licence to commence prior to granting of such approval. In granting such approval, the licensing authority may consult any such other advisors, organisations or stakeholders as may be required at their discretion. The CBPP must be consistent with the marine license application and supporting information. All works must proceed in accordance with the approved CBPP. The CBPP must include the following: a) Details of the location of all works relating to the license and cable laying techniques:	Addressed through provision of this document and associated plans *(6) (1AA0392078 Construction Method Statement & 1AA0295404 Cable Burial Protection Plan)* *(9) (1AA0392078 Construction Method Statement & 1AA0295404 Cable Burial Protection Plan)* *(19) (1AA0295404 Cable Burial Protection Plan)* *(19.a) (1AA0392078 Construction Method Statement)*
Shetland Islands Council Marine Works Licence 2020/011/WL (2.) *Prior to works commencing a <u>Construction Method Statement (CMS) and Operations and Maintenance (O&M)</u> requirements document must be submitted to the Planning Authority and agreed in writing. This includes details of* the cables specification, commencement dates, duration and phasing of key elements of construction, vessel management plan (VMP) and pollution prevention	Addressed through provision of this document and associated plans *(2) 1AA0392078 Construction Method Statement* *(2) A-200409-S04-TECH-004 LT09 Shetland HVDC Link Inspection, Repair and Maintenance Plan for (O&M)*

measures and should be cross-referenced with the Construction Environment Management Plan (CEMP). The purpose of the construction method statement should also be clear, and the inter-relationship with the CEMP fully explained. Reason: To fully inform the deployment of the cable details and to prevent adverse impacts on the environment.]	*(2) 1AA0428959 Vessel Management Plan* *(2) 1AA0395444 Construction Environmental Management Plan (Marine CEMP)* *A-200409-S04-TECH-004 LT09 Shetland HVDC Link Inspection, Repair and Maintenance Plan*
[i] details of the cables specification	Section 4.1
[ii] commencement dates	Section 3.5
[iii] duration and phasing of key elements of construction	Section 3.5
[iii] vessel management plan (VMP) and pollution prevention measures	Reference [5] and [12]
[iv] and should be cross-referenced with the Construction Environment Management Plan (CEMP	Reference [8]
[v] The purpose of the construction method statement should also be clear, and the inter-relationship with the CEMP fully explained.	Section 4.3.2

Table 3-2: Document structure for license requirements

Section of this Document		Contains information on:	Addresses Requirement
Section 1, page 14	Introduction	• Purpose of this construction method statement • Background information on the Projects • Interrelationship with and reference to CEMP	2.[iv, v]
Section 4.1 page 22	Cable Design	• details of the cables specification	2.[i]
Section 3.5, page 21	Project Timelines	• commencement dates • project schedule • duration and phasing of key elements of construction	2. [ii]; [iii]
Section 15 and ref [5]	Environmental Implications	• vessel management plan (VMP) and pollution	2.[iii]

Section of this Document		Contains information on:	Addresses Requirement
[12]		prevention measures	
Section 2	Summary	• Summary of all of the above sections	2

3.5 Schedule of Planned Offshore Works

Table 3-3 details the project schedule overview for the planned HVDC Link construction activities, planned period and estimated durations. A further detailed timeline is shown in Appendix B.

Table 3-3: Project Schedule Overview

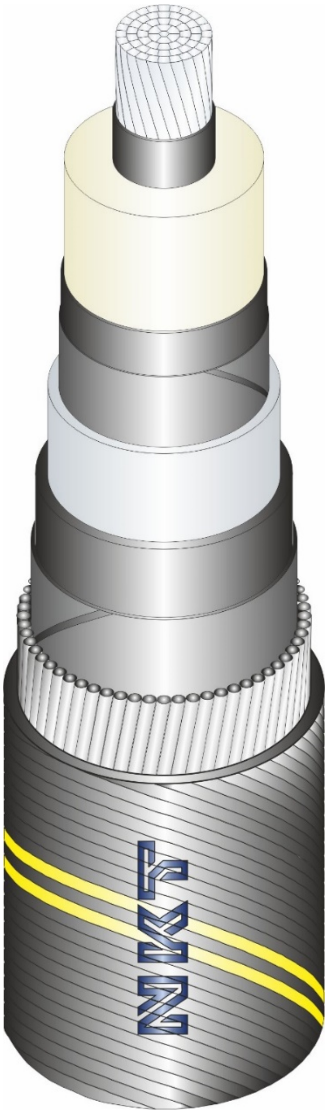
Offshore Operations	Start Year	Est. Marine Activities
Survey for Engineering and UXO	Q2 2021	~45 Days
Landfall preparations and pull-in Shetland Weisdale Voe	Q2 2023	~30 Days
Landfall preparation and pull-in Caithness, Noss Head	Q2 2022 and Q2 2023	~30 Days
Route Clearance (Boulders)	Q3 2021	~75 Days
Route Clearance (PLGR & OOS Cables)	Q2 2022 and Q2 2023	~20 Days
HVDC Submarine Cable Laying (3 Campaigns)	Q2 2022 and Q1-2 2023	~70 Days
Pull-in Caithness	Q3 2022	~3 Days
Pull-In Shetland	Q2 2023	~3 Days
Post-Lay Cable Burial >10 m water depth	Q3 2022 and Q2 2023	~150 Days
Post-Lay Utility Crossing Protection	Q4 2022 and Q3 2023	~10 Days
Remedial Protection by Rock Placement	Q4 2022 and Q3 2023	~110 Days

4 Cable Infrastructure Description

4.1 HVDC Cable Specification

Electricity will be transmitted using two HVDC submarine cables. The circuit will comprise two separate power cables, one per pole, and a separate fibre optic communications cable. The two HVDC cables will be installed in a bundled configuration with the fibre optic cable placed in between the HVDC cables as shown in Figure 4-1and Table 4-1. Bundling will be conducted onboard the lay vessel by winding yarn in a single or crossed direction around the three cables.

Table 4-1: HVDC Cable Specification



Submarine cable (single cable specification)	**Unit**	**Note: Properties to be doubled as bundled (2) cables are installed together (side by side)**
Protective sheath:		
- Material		Polypropylene yarn
- Nominal thickness	mm	2x2
Overall		
Overall cable diameter	mm	125
Weight, in air /sea water	kg/m	32 / 19

Figure 4-1: HVDC Cable bundle design

4.2 Fibre Optic Cable Specification

A GJMLTV 10-ton SA 12-192 Loose tube submarine fibre optic cable shall be installed with the bundles HVDC cables.

Features

- For unrepeatered systems
- Water depth 3000 m
- Compact design, only 22 mm in diameter
- 12-192 optical fibers
- With or without electroding conductor
- Single layer steel wire reinforcement
- Hydrogen protected
- Outer protection polypropylene yarns or polyethylene sheath

Design

1. Primary coated fiber .... Silica, acrylate
2. Filling compound .... Thixotropic compound
3. Tube .... Stainless steel
4. Sheath .... Polyethylene, black
5. Armoring............................ Galvanized steel wires, single layer 14 x ø3.0 mm

6 Filling compound............ Bitumen

7 Wrapping .... Polyester tape

8 Wrapping .... Polypropylene yarns or HDPE sheath

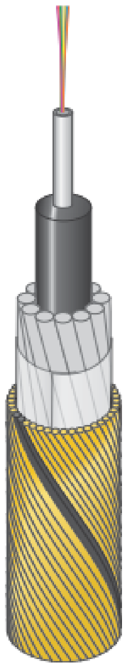


Figure 4-2: Fibre Optic Cable Specification

4.3 Submarine Cable Route

4.3.1 Route Overview

The planned subsea HVDC Link cable route shown in Figure 2-1 runs from Weisdale Voe in Shetland to Noss Head in Caithness and is approximately 253 km in length. The Licensee has a 200 m wide installation corridor which has been permitted as the cable installation corridor, in which the HVDC Link subsea cable shall be installed.

The HVDC Link cable route shall be optimised during detailed route engineering by NKT to establish the design route within this permitted route corridor, based on the cable route position list submitted to as part of this Permit application, reference to RPL_LT09_02_20190605 which has been provided to NKT.

The installation methodology is based on a pull-in of the subsea cable at each of the landfall locations, at Noss Head and Weisdale Voe, to optimise the cable vessel capacity and vessel availability, the cable lay schedule will be performed in three separate campaigns of 98 km /

57 km / 98km and will incorporate two (2) in number of offshore joint locations. The cable pull-in operations would be required to pull-in the cable to the landfall Transition Joint Pit position onshore, which are set back from mean high water springs and where jointing shall occur between the land cable and the submarine cable.

The planned lay direction and sequence will be as detailed:

Table 4-2: Cable lay directions

Campaign	Lay direction	Month / Year	Est. Activity Days
Campaign 1	From Noss Head (98km)	June/July 2022	17 days
Campaign 2	From Weidale Voe (57km)	March/April 2023	10 days
Campaign 3	CP2 (Joint) southerly direction lay cable to CP1 (Joint) (98km)	June/July 2023	25 days

Marine Licensing authorities and all relevant stakeholders shall be informed regarding any changes to the planned works.

4.3.2 Cable Protection Overview

Cable protection shall primarily be by means of jet trenching the HVDC cable bundle to provide the required depth of lowering and depth of cover. In those sections of the cable route where the seabed conditions restrict trenching depth of lowering or cover or the marine permit conditions prevent the use of a trenching method, then remedial rock placement would provide the required depth of cover to protect the HVDC cable bundle, as shown in Figure 4-4 and as described in the Cable Burial and Protection Plan ref. [7] except for when:

- The HVDC cable bundle crossing the MPA of the horse mussel bed, where cable protection by means of a Cable Protection System (CPS); Uraduct (or similar) or Cast-Iron Shells shall be installed.
- The HVDC cable crossing other cable or pipe line assets, where the protection method shall be in agreement with the crossed asset owner.
- For nearshore approaches crossing MHWS, (Noss Head) where Horizontal Directional Drilled steel ducts or (Weisdale Voe) where PE ducts are installed.
- For the both nearshore approaches, where a CPS would be used.
- Temporary cable protection is required for cable pinning or free-span support, where clump weights, filter rock bags or concrete mattresses could be used.
- Where through further detailed burial assessment engineering and/or through trenching performance, NKT and SHE Transmissions agree that trenching using mechanical cutting tool would further improve the depth of lowering and reduce the estimated areas for remedial rock protection.

Table 4-3 shown below provides as summaries the cable protection methods planned for the marine construction works.

Table 4-3: Proposed burial tools - overview base case

Location	Activity	Tool	Vessel / Equipment
Landfall, Weisdale Voe	Cable burial/pre-installed PE Pipe	Excavation / installation of pipes	Backhoe dredger, barge, work boats, rock chiselling tool or similar
Weisdale Voe to Noss Head MPA East boundary,	Post-Lay Cable Burial >10 m water depth	Jet Trenching / Mechanical Cutting	T1200 / T1500 / i-Trencher or similar
Noss Head MPA	Pre-installed uraducts or similar crossing the MPA,	Cable Lay Vessel	Cable Lay Vessel
Weisdale Voe to Noss Head MPA East boundary,	Pre-lay / Remedial rock placement	Rock Fall Pipe Vessel	Rock Placement Vessel
Noss Head MPA West boundary to HDD ducts	CPS, Post lay Rock	Divers & Rock placement	Dive work boat, Rock Placement Vessel
Landfall, Noss Head	Pre-installed ducts	Horizontal Directional Drilling	Work boats, barge.

Figure 4-3: Primary Burial Methodology

Primary Burial Methodology						
Open Trench (km)	Rock Placement Length (km)	T1200/T1500 Trenching Pass (km)	T1200/T1500 Remedial Trenching Pass (km)	Remedial Rock Placement Length (km)	CPS (Uraduct or Similar) (km)	HDD Duct (km)
0.15	8.981	241.9	67.083	81.921	2.601	0.561
0.06%	3.56%	95.79%	26.57%	32.44%	1.03%	0.22%
0.15	**8.981**	**241.9**	**67.083**	**81.921**	**2.601**	**0.561**

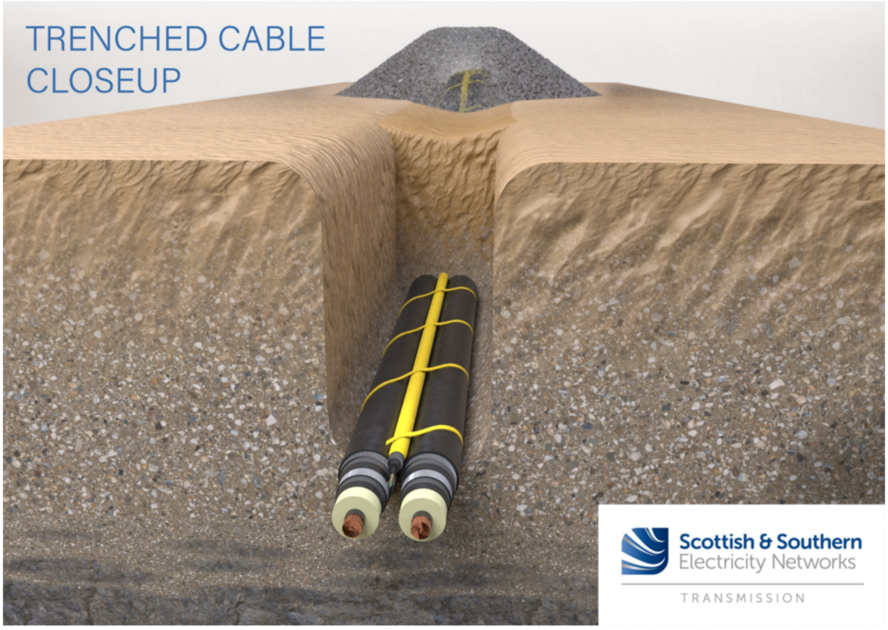


Figure 4-4: HVDC Cable bundle cable protection profile

4.4 Cable Crossings

The Shetland HVDC Link cable and pipeline crossing are listed in the table below. The cable protection design for cable and pipeline crossings can be found in document Ref. [7] with a summary covered in this section.

The table in Table 4-4 details the Shetland HVDC Link cable crossings of "in service" and "out of service" crossed assets along the cable route. The Kilometre Point (KP) references start from Weisdale Voe landfall at KP0 as shown in the route image Figure 2-1.

Table 4-4: Cable and Pipeline Crossing List

No.	Name	Status *)	KP
1	SFF Flotta Marine Cage Fish Farm (Weisdale) **(Note: In proximity to but asset not crossed)**	Proximity	Weisdale (TBC)
OOS1	OOS cable UK Faroes	Out of service	TBC
OOS2	UK-Faroes_2_Rev1	Out of service (since 1994)	30.5
2	SHEFA-2 Seg 7-3 FOROYA TELE	In use	30.5
3	TAT 14(K)	In use	63.8
4	Havfrue Segment 5 Issue 6	In use	68.5
5	Atlantic Crossing 1 (AC1)	In use	71.8
6	TAT 10B	OOS	96.2

No.	Name	Status *)	KP
OOS3	OOS - Fair Isle-Sanday	Out of service (since 1945)	103.6
7	New Telecom Cable	TBC	TBC
OOS4	Fair Isle – Taracliff Bay	Out of Service (since 1972)	120.1
OOS5	Orkney - Shetland	Out of Service (since 1994)	125.1
8	SHEFA-2 Seg 8	In use	139.6
OOS6	Sandwick Bay – Sinclair's Bay (north)	Out of Service (since 1978)	159.5
OOS7	Sandwick Bay – Sinclair's Bay (south) (2 circuits)	Out of service	TBC
9	30¨Piper to Flotta Oil	In use	182.0
10	SHEFA 2 Seg 9	In use	226.4
11	Subsea 7 Bundled tow route - Start of 25m Trench Transition Zone	Active	240.2
	Subsea 7 Bundled tow route - Start of cable protection system		240.3
	Subsea 7 Bundled tow route - Start of Cable at nominal 1.5m burial		240.3
	Subsea 7 Bundled tow route - Bundle Tow corridor Xing		240.4
	Subsea 7 Bundled tow route		241.1
	Subsea 7 Bundled tow route - Bundle Tow corridor Xing		241.8
	Subsea 7 Bundled tow route - End of Cable at Nominal 1.5m burial		241.9
	Subsea 7 Bundled tow route - End of 25m Trench Transition zone		241.9
	Subsea 7 Bundled tow route - End of Cable protection system		241.9
12	Start of 100m run-in (No Trenching/Rock Placement Zone	Marine Protected Area	249.9
	Start of Horse Mussel Reef		250.0
	End of Horse Mussel Reef		250.8
	End of 100m run-out (No Trenching/Rock Placement Zone)		250.9

4.4.1 Crossing Installed Cables and Pipelines

The crossed assets as, detailed in Table 4-4 above, shall be protected by means of pre-lay crossing protection in the form of a pre-installed concrete mattresses or pre-lay rock berm installed over the buried or partially buried crossed asset. The crossing design would be first approved by the crossed asset owner, with the conditions required detailed in each SHE Transmission Crossing Agreement. The installed HVDC Link cables would then cross as close to perpendicular to the crossed asset. Then a post-lay rock berm would be installed over the HDVC Cable Link and the crossed asset.

For the crossed asset of the exposed 30¨Piper to Flotta Oil pipeline (Crossing No. 9), as in the above paragraph, NKT would install a pre-lay rock berm and post lay rock berm, as agreed in SHE Transmission Crossing Agreement with the asset owner.

4.4.2 Crossing of Out of Service (OOS) assets

For identified Out of Service assets which cross the HVDC Link cable route, these OOS will be cleared by the cut and peeled back method prior to the laying campaign. The procedure for cut and peeled back will follow ICPC guidance. As described in the CBPP ref. [7]

4.4.3 Crossing of MPA Horse Mussel Bed

At the southern end of the route, the cable route crosses the Noss Head Marine Protected Area (MPA), the largest horse mussel bed in Scottish Waters. The Cable route runs in parallel with the Caithness Moray HVDC cable and complying with licensing conditions cable burial and rock placement will not be permitted within 100 m of the horse mussel bed feature. An alternative means for cable protection within this area is required.

NKT plan to install a cable protection system, such as half shells (Ballasted Uraduct or similar or Cast-Iron Shells), approximately 948m (including a run in/out of 100 m) through the horse mussel bed MPA. Further detailed engineering and pre-lay survey is required to define the MPA feature extent along the route, optimal cable route and cable protection system to provide a stable cable system through the MPA crossing. This is further described in the CBPP ref. [7]

4.4.4 Crossing of Subsea 7 Bundle Tow Route

As an additional protection measure, consideration has been given to installing a CPS (Uraduct type or similar) during cable lay and prior to trenching the cable for the crossing with the Pipeline Bundle tow route of Subsea 7.

The crossing is located 9km east of Noss Head and the cable laid with CPS will also be trenched using jet trencher with a target Depth of Lowering (DoL) 1.5 m with a DoC of 0.6m. This is according to the subsea cable burial specifications within the Cable Burial Risk Assessment (CBRA) [17].

Whilst the CBRA concluded that the risk of a catastrophic failure, which would result in the bundle being dropped to the seabed, is very low. Specific attention will be required to ensure that the cable is suitably installed into the seabed to provide protection from potential dropped objects and sediment movement due to potential abrasion from ballast chains located on the pipeline bundles.

The zone of required additional protection has been identified as 1,671 m between KP240.2 and KP241.9, allowing for the width of pipeline bundle tow route 1,571 m (including run in/out of 50m). As described in the CBPP ref. [7].

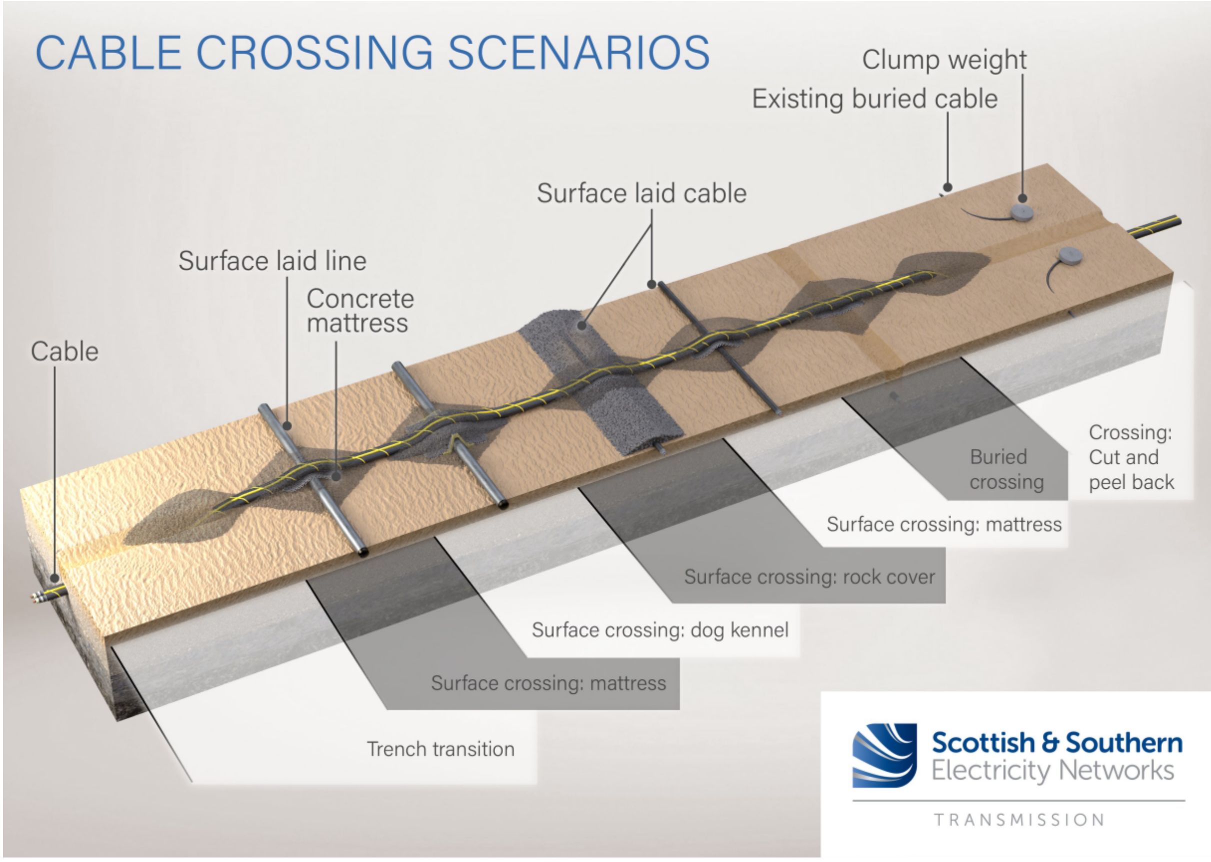


Figure 4-5: Cable Crossing Scenarios

4.4.5 Crossing Protection Schedule

Cable crossing protection for all other crossed assets (not listed in Table 4-5), shall consist of pre-installed concrete mattresses, this protection activity shall occur just before each cable lay operation. Then post lay rock placement to cover the installed HVDC bundle and concrete mattresses, as detailed in Table 3-3. The estimated duration for installing concrete mattresses is less than 24 hours for each crossed asset.

Table 4-5: Crossing Protection Schedule

Activity	Schedule	Est. Activity Days
Pre-lay rock berm – Flotta to Piper pipeline	March/April 2022	2d
Post-lay rock berm – Flotta to Piper pipeline	Oct/Nov 2022	2d

Horse Mussel Bed Crossing Protection	June/July 2022	1d
Subsea 7 Towed Pipe Crossing	June/July 2022	2d
Nearshore HDD pipe exit – Noss Head	July/September 2022	15d
Nearshore PE pipe exit – Weisdale Voe	April/June 2023	15d

4.4.6 Concrete Mattresses

Concrete mattresses shall be used at each cable crossing to protect the crossed product from the installed HVDC cable bundle and post lay installed rock berm.

Mattresses placed at the crossing locations will ensure a separation if required. In this document an industry standard concrete mattress of 6 m x 3 m x 0.3m (l x w x h) have been used for the pre-lay crossing design. The submerged weight of a mattress is 4775 kg with concrete density of 2400kg.m3. Installation of mattresses shall be done using the vessel crane and lifting frame.

Figure 4-6: Concrete Mattresses

5 Nearshore Works - Weisdale Voe – Landfall PE Pipe

5.1 Nearshore Cable Protection

NKT plans to install PE ducts of circa 450mm diameter, either two (2) ducts in a single trench for each HVDC cable or use one (1) duct for cable redundancy and pull the bundled cables through a single duct to the transition joint bay on shore. A trench shall be excavated of 150m to 180m length from the transition joint bay close to the shore line out to the nominated exit point at approximately 10m LAT, two long PE ducts would be installed out from the shore line as shown in Figure 5-1. NKT plan to move the cable route to the left away from the rock outcrop close to the current route, within the licensed corridor.

NKT require to conduct further detailed nearshore survey and engineering to be able to optimise the cable protection solution for this location.

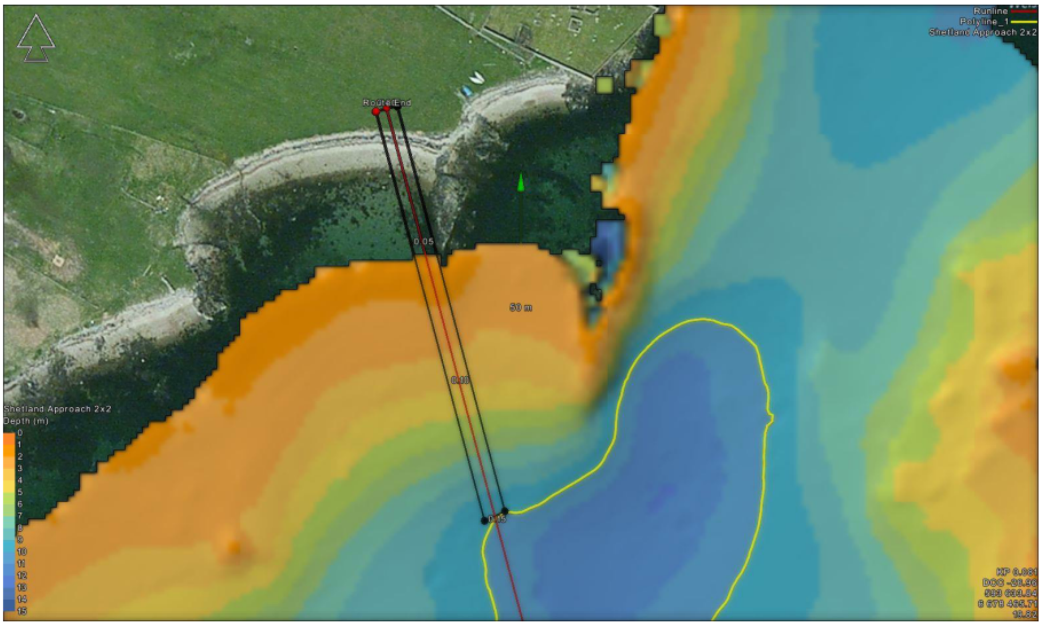


Figure 5-1: Shetland Landfall Location

Work would be carried out by local civil contractor using a backhoe excavator (typical 30-40 tonnes), working from shore and on a spud-leg barge or anchored work pontoon, where water depths require. A workboat (multi-cat or similar) will be used to manoeuvre and support the spud-leg barge or work pontoon.

Figure 5-2: Example of nearshore equipment

Where shallow bedrock is encountered a hydraulic chiselling or rock cutter tool may be required to deepen the trench of up to 1.8m (depth to be verified). The PE ducts would be butt welded to length then floated out and lowered in the pre-excavated trench and then backfilled, with filter layer of gravel, then primarily use of natural backfill and crushed rock, where an armour layer is required. Natural backfill would be spread to re-profile with the surrounding seabed area. The PE duct would have a small bellmouth attached to aid cable pull-in, which if fitted to submerged end of the PE duct to aid the pull-in of the cable. The duct bellmouth end shall then be protected by rock, post cable pull-in.

First layer around ducts shall be filter layer consisting of gravel. The recommended armour layer grading is 1-8‘‘rock. As can be seen in Figure 5-3, the filter layer gravel shall fill the trench to 300 mm above apex of duct. Retained natural backfill materials would be placed over the layer of rock armour, any excess material being graded over the cable trench, as required. The diagram shown in Figure 5-3 is an example trench design, NKT require to conduct further detailed engineering.

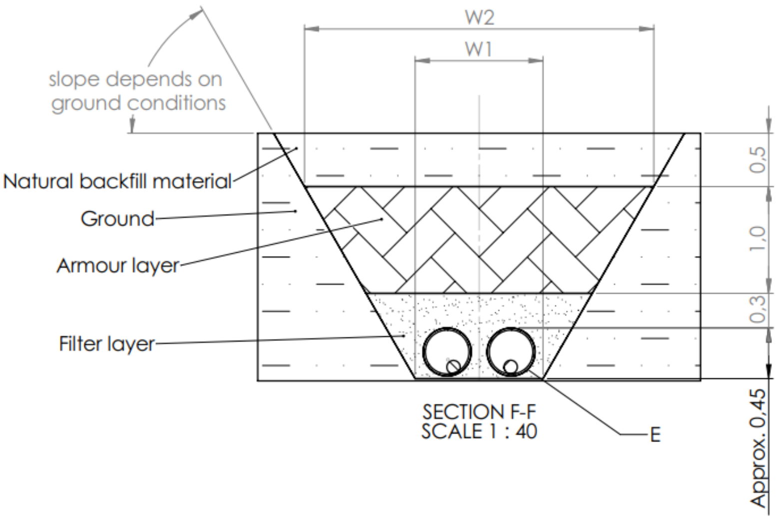


Figure 5-3: Example PE ducts & trench design drawing

To control the spread of disturbed sediment created from nearshore excavation of seabed materials, a silt curtain system as shown in Figure 5-4 would be used. Silt curtains would be anchored around the working perimeter to allow sediment to settle naturally and prevent spread with the tide run to aquaculture sites in the Voe. The working area would be monitored by an Environmental Clerk of Works during marine operations when seabed is disturbed.

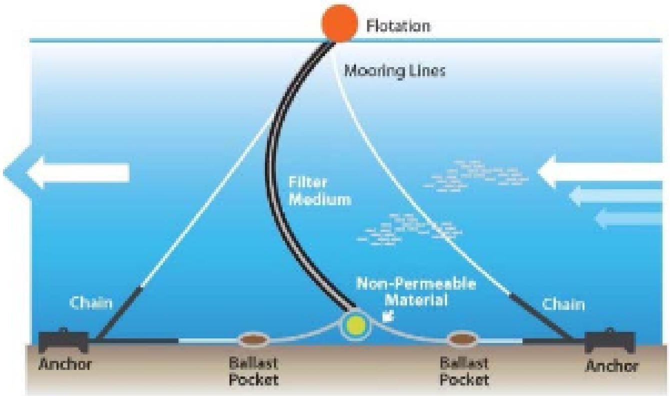


Figure 5-4: Image of a Silt Curtain arrangement

An alternative design to the Weisdale Voe landfall is also being considered and may be selected as the preferred option pending further survey and detailed engineering. The alternative solution consists of using cast-iron shells around the cable, either as a bundled cable or as single protected cables, seen in Figure 5-5, which are pulled in to a pre-excavated trench down to the required depth of lowering between 1.0m to 1.75m, then primarily backfilled with natural materials and an armour layer of rock, over the cable where design protection is required. Excess natural backfill materials will be graded across the cable trenched and profiled with the surrounding area.

Cast-iron shells may also require pinning in the nearshore sections where the cable rests on the seabed or rock outcrops to give temporary or permanent stability due to metocean analysis results, where due to limiting water depth of the cable route, trenching or rock placement cannot occur for due equipment and vessels limitations.

Figure 5-5: Cast-Iron Shells leading from the landfall

Through further detailed nearshore engineering NKT shall identify the accepted cable protection methodology to comply with the Shetland Island Council Marine Permit consents conditions and environmental requirements that apply, were NKT cannot excavate to the required design depth to install protection for the PE duct, then NKT's next preferred design is to reduce the length of the PE duct and include the use of cast-iron shells laid over bedrock, with rock pinning and/or rock cover.

5.2 Planned Schedule

Table 5-1: Nearshore Weisdale Voe Schedule

Activity	Schedule	Est Activity Days
Nearshore Site Works (all works)	April/June 2022	80 days
Trench Excavation Works	May 2022	30 days
Trench Survey Works	May/June 2022	5 days
Backfill of Materials	June 2022	10 days

Works would be carried out during day light hours based on a 12-hour working day (6 days a week).

6 Nearshore Works – Noss Head – Landfall HDD Ducts

6.1 Nearshore Cable Protection

The landfall site at Noss Head, Caithness shown in Figure 6-1, would be prepared with three (3) planned Horizontal Directional Drilled (HDD) ducts as shown as (red) lines in Figure 6-1, although consents application has been approved for up to five (5) HDD Duct to be installed. Of the three (3) planned HDD ducts to be installed, NKT plan to used only two (2) for pulling cables through, with the third as a spare contingency option.

The NKT shall install three (3) HDD steel ducts of 324mm in diameter of approximately 560m in length from the transition joint bay location (HDD Compound) to extend to outside the wave break zone, within Target Zone 2 (orange area), to exit in at rock outcrop.

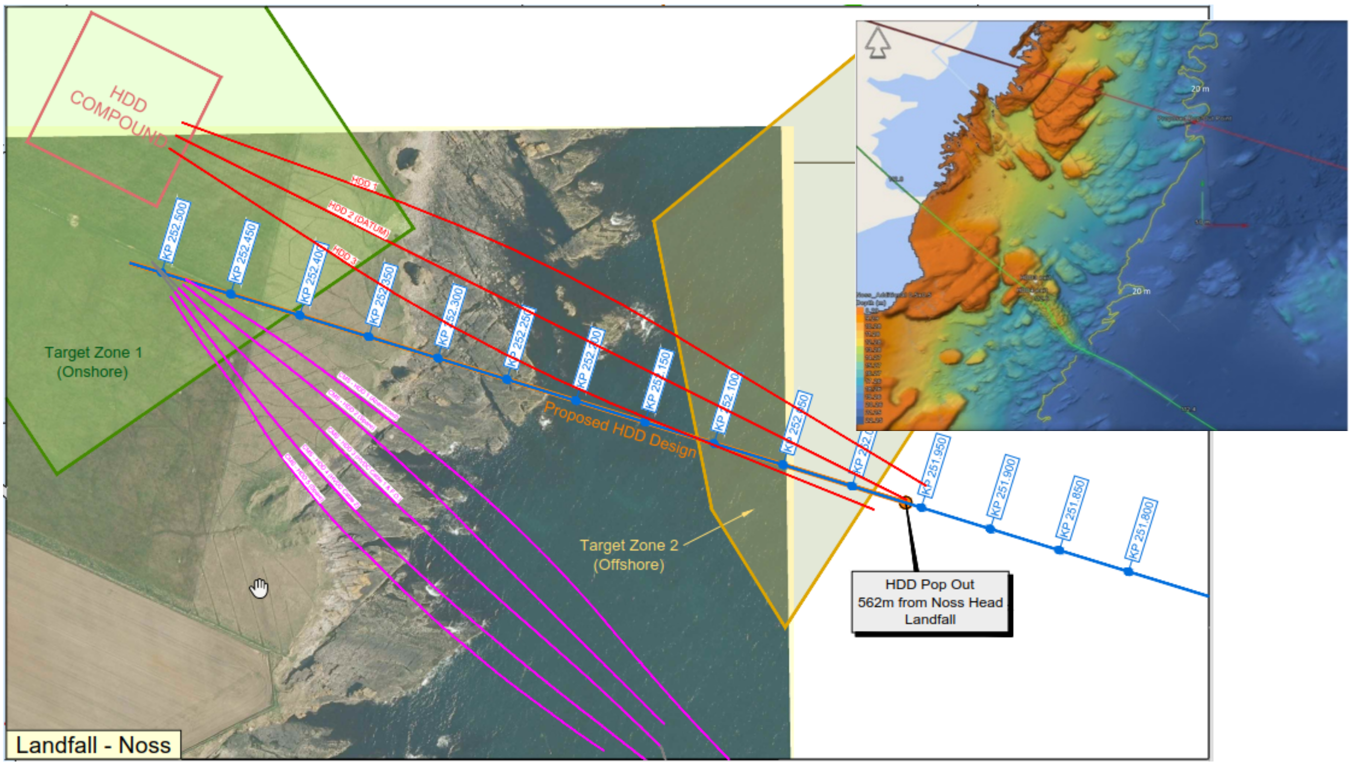


Figure 6-1: Noss Head Landfall and HDD duct routes

Three (3) pilot holes shall be drilled of diameter 444mm from the landfall HDD compound, with each HDD route completed in turn and then the steel casings shall be pushed in from shore to extend out from the identified rock face at the 20m LAT depth, with each duct to exit above the seabed circa 1.0 m, shown in Figure 6-2. The ducts shall be cleared and gauged, then a flange and sealing plate shall be fitted at the duct exit. Then remain sealed from drilling works completed Q3 2021 until start of the pull-in preparation works in Q2 2022.

Then NKT shall prepare for cable pull-in and install three (3) bellmouths, complete clearance checks and pre-position a winch, pull out the messenger wire and retain with a clump weight ready for cable pull-in. These works shall require the use of a barge with crane or winches and the use of divers.

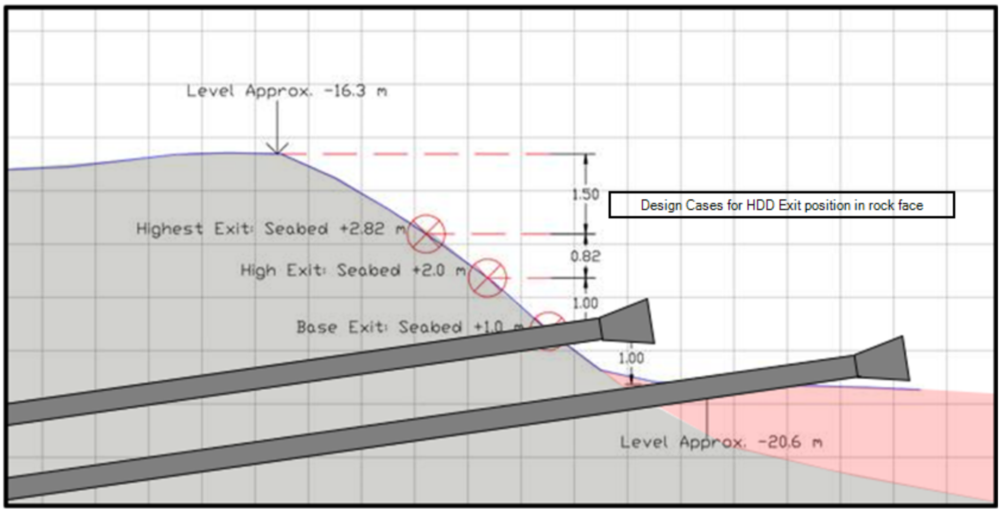


Figure 6-2: Design cases for HDD Exit Position - Noss Head

The HVDC cables and fibre optic cable shall be pulled in through the HDD ducts to the landfall joint bay location, using the pre-installed duct messenger wire and pull-in winch wire, which is recovered by the CLV ROV to deck and then connected by shackles to the HVDC cable pull-in head. The cables shall then be pulled in singularly by the landfall winch and secured for jointing. The duct ends will then be sealed by divers at the bellmouth and then the ducts are filled with bentonite from landfall and vented from the subsea exit with work carried out with a workboat and divers for these activities.

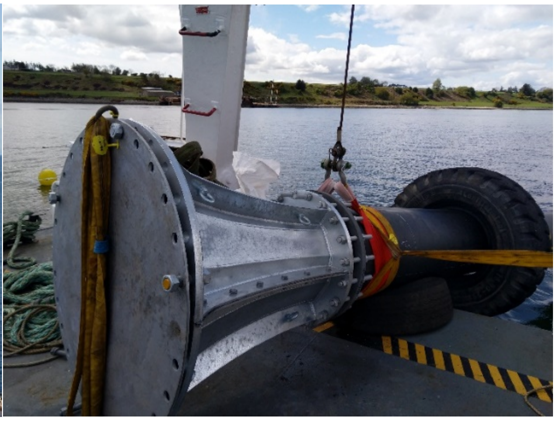


Figure 6-3: Woodstock, self-propelled crane barge **Figure 6-4: Example HDD Bellmouth and sealing plate**

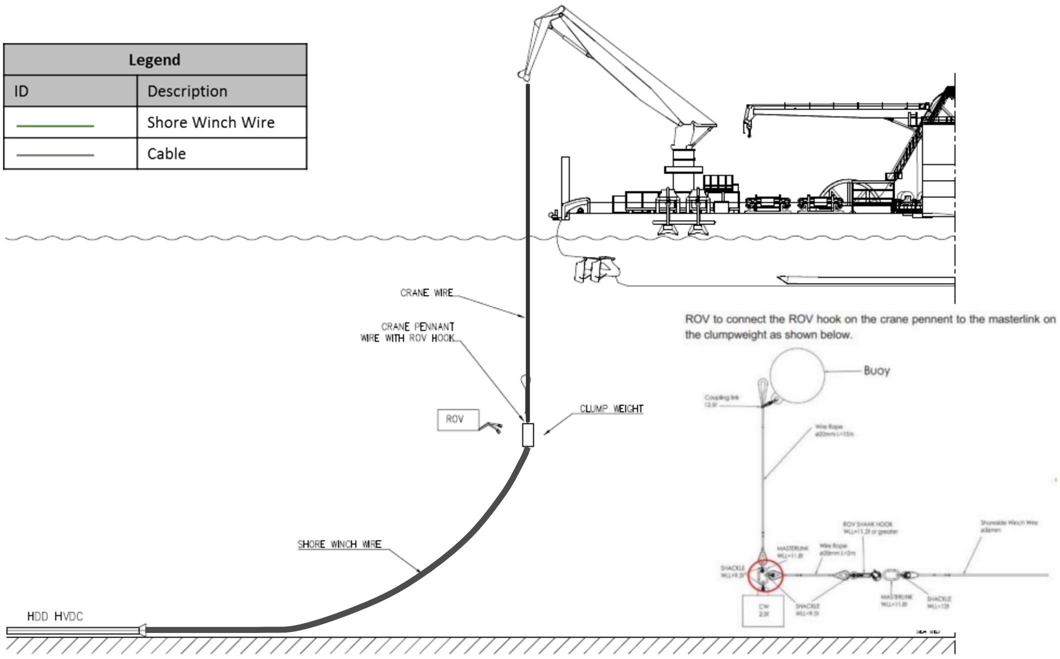


Figure 6-5: CLV recovery of messenger wire

6.2 Drill Site

The drill site shall be located in the same field location at Noss Head used in the Caithness-Moray project via a single work site access track. The site shall be prepared before the arrival of HDD equipment, vehicle access and the concrete drilling pad and site perimeter fencing.

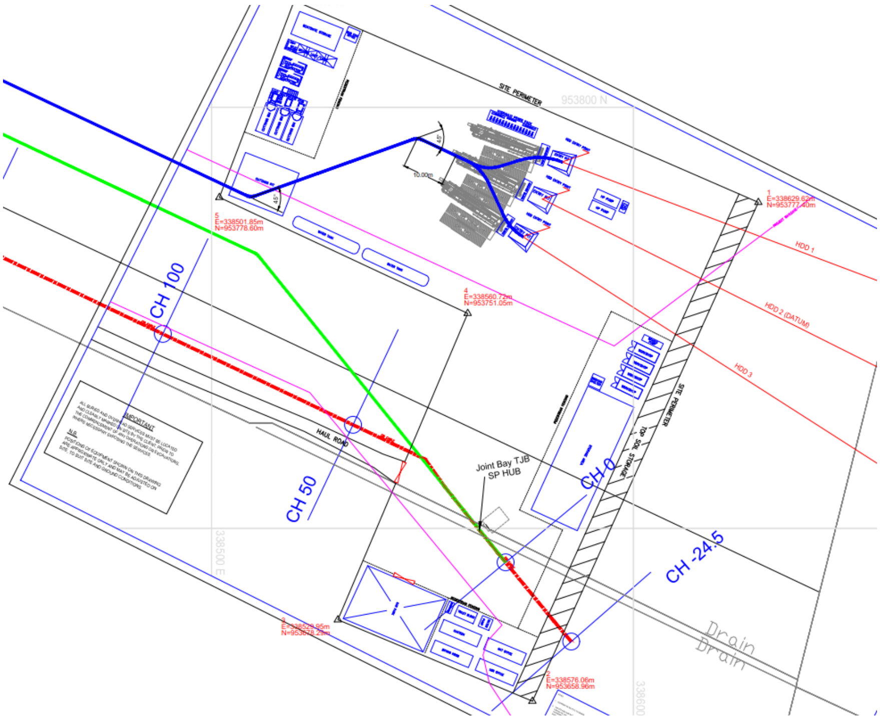


Figure 6-6: Noss Head Site Layout

6.3 Construction Method Statement – Summary of HDD Works

A pilot drill is planned for the 1st drill (HDD1) of circa 550m meters in length which cross the Powmad Fault Zone to the target exit point. Once completed the 324mm steel ducts shall be pushed through the 444mm pilot hole by the drill rig. The casing is designed that the ducts are internally flushed for their full length.

The pilot string will consist of 7⅝" (193mm) drill pipes, an 8" (203mm) diameter non-magnetic drill collar, a 9⅝" (243mm) mud-motor and a 17½" (444mm) diameter tri-cone rock bit. All components have threaded connections and are screwed together and tightened to the correct make-up torque. Drill fluid is pumped throughout the pilot drilling operations.

The mud motor consists of a rotor set in an elastomer stator. As the drill fluid is pumped through the mud motor, the rotor rotates within the stator. The rotor is attached to the tri-cone bit via a drive shaft and, hence, the bit rotates as the drill fluid is pumped. The rotational action of the bit, coupled with a push force from the drilling rig, cuts through the material ahead of the bit, thus forming the hole. The mud-motor has a bend approximately 3m from the end. Therefore, as the hole is formed, it follows a curved bore path.

The process of pipe installation involves the welding together of pipes on site as the pipes are pushed into the drilled hole. The steel pipes would be prepared well in advance of mobilising to site with a short collar section at one end. This collar would slip over the plain end of the superseding section of pipe and be welded together. The drill rig then pushes the extended string into the pre-drilled hole and the process is repeated until the full length of the bore has been cased. This casing duct can then be left in-situ for the subsequent cable installation process which can be programmed independently from the drilling operations.

Given that the drilling will be through strong sandstone formations for the vast majority of the drill length, drill fluid breakout is highly unlikely. However, as the land above the drills is environmentally sensitive, pressure sensors will be incorporated into the drill string to mitigate the risk of a breakout occurring. These pressure sensors within the drilling head monitor the pressure of the drill fluid within the borehole.

The exit point is below water and, as such, there is little possibility to contain and control breakout as the drill approaches the exit point. Prior to breakout (c. 50m) a dedicated cleaning run of the bore using standard drilling fluid will be performed so as to flush any residual cuttings or detritus from the borehole. The drilling assembly is then run back into the hole and the drilling continues until the drill bit breaks through onto the seabed.

6.4 Post Lay Cable Protection

From exit point and approximate 50m outwards the cable may have a cable protection system as a means of additional protection, in combination with nearshore rock berm to cover the cable and HDD ducts extruding from the rock face. Installed cable protection of type of bending restrictors, uraduct or cast-iron shells (or similar) would be used.

6.5 Planned Schedule

Table 6-1: Nearshore Noss Head Schedule

Activity	Schedule	Est Activity Days
HDD Drilling of (3) Steel Ducts	May - July 2021	90 days
Nearshore Site Works (all)	June 2022	30 days
Preparation Works (open ducts)	May 2022	20 days
Post Installation Works (sealing ducts)	June 2022	15 days

7 Offshore Works – Pre-lay and UXO Survey

7.1 Overview

NKT shall conduct a pre-lay and UXO investigation survey of the cable route licensed corridor to verify the cable route seabed conditions. No UXO clearance or detonation is proposed for the works. These works shall be carried out 12 months in advance of the cable installation and protection works with collected data used for approval of the final construction route with regards to obstructions and areas where seabed intervention shall be required.

A European Protected Species (EPS) license for the marine works will be obtained and appropriate mitigations implemented in respect of the planned geophysical and UXO survey works described below.

The pre-lay & UXO investigation survey shall be divided in to offshore works and nearshore works which fall in to the limitation of the vessel and equipment to be used. Geophysical survey equipment shall be either a towed array, vessel mounted, pole mounted or ROV fitted equipment to allow for the required seabed information to be collected for processing. Survey lines shall be conducted with the route divided sections as blocks, this is to allow for micro route engineering to occur offshore and to optimise the cable route survey activities.

A detailed offshore and nearshore geophysical survey shall be carried out by a competent survey contractor using the following methods from the survey vessels:

- Multi-Beam Echo Sounder (MBES)
- Side Scan Sonar (SSS)
- Sub-Bottom Profiler (SBP)
- Gradiometer/Magnetometer (Magnetic Data)

A towed ROV shall be deployed and fly low over the seabed to capture the data and map the seabed. A ROV shall be equipped with a video system, cameras for benthic habitat confirmation and inspection of anomalies, and a Teledyne cable tracking sensor for tracking the position of crossing cables. Ultra-Short Baseline System (USBL) and transponders will be used to provide positioning of remote operated equipment used during the pre-lay & UXO survey. This type of survey equipment will be used on all other construction vessel for remote operations to lay and protect the HVDC Link.

The survey shall also cover those crossed assets to pin-point the crossed position and direction and depth for each crossing design.

Route magnetic data shall be acquired in the route corridor to identify magnetic targets and any potential Unexploded Ordnance (UXO). A towed array (MagSense) shall be used with an array of gradiometers for the planned line surveys. Where identified targets require individual inspection a ROV with magnetometer shall be used for localised inspection. Survey lines shall be based on NKT UXO consultant and the completed desktop study and Risk Mitigation Strategy for the cable route. Where possible the route shall be designed to avoid the metallic target list for potential UXO's via micro-route engineering. If, any surface targets are confirmed as potential UXO's then notification shall be given to the appropriate authorities to arrange for disposal action.

Geotechnical soil Core Penetration Testing (CPT) and Vibrocore (VC) samples have been considered by NKT for those areas where there is a shortfall to the project survey data. These locations are:

- Weisdale Voe nearshore with 750m to the landfall cable route, to support the cable nearshore protection design
- Offshore where the cable route changes significantly from the route centreline and new soil data is considered necessary to support the cable intervention design.

This scope of work is still to be confirmed necessary for the project.

7.2 Planned Schedule

Table 7-1: Pre-Lay Survey Schedule

Activity	Schedule	Est Activity Days
Offshore Pre-lay survey (Geophysical)	May/June 2021	20 days
Offshore Pre-Lay UXO survey	May/June 2021	32 days
Nearshore Pre-Lay & UXO Survey (Noss Head)	June/ July 2021	10 days
Nearshore Pre-Lay & UXO Survey (Weisdale Voe)	June/July 2021	14 days
Offshore Geotechnical (TBC)	June/July 2021	7 days
Nearshore Geotechnical (TBC)	June/July 2021	7 days

7.3 Construction Method Statement – Summary of Pre-Lay Survey Works

7.3.1 Pre-Lay & UXO Survey

The plan to conduct a pre-lay & UXO survey is in order to confirm the seabed profile, soil layers, structure and potential hazards. The types of survey to be conducted are shown in Table 7-2.

Table 7-2: Pre-Lay & UXO Survey - Technical Solution

Equipment	Nearshore Survey Operations	Offshore Survey Operations
Vessel	Suitable Nearshore Vessel	Suitable Offshore Vessel
Bathymetry	Hull mounted R2Sonic 2024 or similar	ROTV mounted NOrbit WBMS 400kHz or similar
Side Scan Sonar	Edgetech FS4200 300-900kHz or similar	ROTV mounted Edgetech FS4200 300-600kHz or similar
UXO Detection Method	Gradiometer or Magnetometer or similar	Dual MagSense or similar
Crossing Survey	N/A	Teledyne TSS440
Sub-Bottom Profiler	Innomar SES 2000 Compact or similar	Innomar SES 2000 Standard or similar
Drop-Down Camera	N/A	SeaSpyder or similar

7.3.2 Mobilisation and Calibrations

During mobilisation of each vessel, all survey systems will be installed, tested and calibrated. Where possible, the equipment will be wet-tested and verified, where after it will be calibrated, and function tested in port and / or on-site.

7.3.3 Data Acquisition

Data will be acquired on a route section basis. Sections may be split where significant route deviations (>15°) occur, by length or where there may be change in the target detection depth or route depth profile. Such splits have already been provisionally derived based on the current available data but may be subject to amendment in the field.

Offshore and nearshore vessels will be used to collect the survey data. In the nearshore locations shallow draft vessels will be used in conjunction with sub-surface and surface-towed sensors.

For all vessels the SSS, SBP and MBES data will be collected first and used to map the bathymetry and surface objects along the centreline of the route (to allow for the towing of the gradiometer array as close to the seabed as safely possible). Following this the magnetic gradiometer data will be acquired.

Line spacing will be sufficient to ensure the required coverage in the geophysical survey specification will be met for all datasets. Any infill required for offline or altitude deviations will be collected the following day or scheduled in the most efficient manner.

7.3.4 Nearshore Survey

The nearshore sections at Caithness and the Shetlands will be surveyed utilizing the vessel mounted MBES and towed SSS (300/900kHz). The two boxes (250m x 250m Noss Head and 500m x 750m Weisdale Voe) will be surveyed.

7.3.5 Offshore UXO Survey

The survey will continue with towing both the ROTV and a single MagSense until the required corridor is covered in the required resolution for the MBES and SSS.

The ROTV is then replaced by a second MagSense system, which enters the 2nd phase consisting of towing two MagSense systems.

A target list for magnetic targets shall be created and the collected data shall be processed and classified by a competent UXO consultant. Those magnetic targets that are then classified as a potential risk to equipment shall be first mitigated by micro re-routing and then by ROV target verification with visual means and use of a dredge pump to clear surface sediment.

7.3.6 Crossing Surveys

The cable and pipeline crossings will be surveyed with the ROTV mounted MBES and SSS to obtain:

- MBES and SSS 100m on each side of the crossing location (Total length is 200m)
- MBES and SSS 200m in length along the crossed location (Total length 100m each side of the crossing point).

Additionally, an ROV survey of the crossing will be performed with Triton XLX WROV to obtain:

- Horizontal position of the crossed asset
- Find Depth of burial with the TSS 440
- General Visual Inspection along the cable trajectory (100m on each side of the crossing location)
- General Visual Inspection along the crossed asset (100m on each side of the crossing location)

7.3.7 Horse Mussel Bed Survey

A video survey line will be acquired using the Triton XLX ROV over a length of 1 km (800m + 100m at the start and end of the HMB).

Additionally, a drop-down camera system or ROV camera will be utilized to obtain stills every 50m along the cable route crossing the MPA.

7.3.8 Aquaculture Sites – Anchor line positional survey

There are uncertainties in the position of Aquaculture site anchor lines and thus, an unforeseen hazard to construction and survey vessels and towed or remote operated equipment. NKT proposes to conduct a video survey, only at those locations where any aquaculture sites are located very close to the cable route corridor. The aim would be to confirm and chart the position any seabed rigging for anchor lines along the cable route in the Weisdale Voe.

8 Offshore Works – Seabed Preparation

8.1 Overview

NKT's plan for seabed preparation include boulder clearance operations to remove specific boulders which would hinder cable lay and trenching operations. To cut and peel back Out of Service (OOS) cables confirmed through asset owner agreement. To conduct Pre-Lay Grapnel Runs (PLGR) prior to cable lay installation campaigns and install pre-lay rock at the Flotta to Piper pipeline crossing and other cable crossing or install concrete mattresses based on the cable protection design requirements for the crossing agreements.

These seabed activities are to remove any seabed debris that would hinder cable lay and trenching operations found in the route corridor. Seabed preparation activities are boulder clearance planned in Q3 2021, PLGR and crossing protection planned for Q2 2022 and in Q1 and Q3 2023.

8.1.1 Boulder Clearance

For those sections of the cable route where numerous boulders / boulder fields are shown, the approach would be:

- Verification of area during the NKT's pre-lay geophysical survey investigation.
- Micro re-route engineering to avoid exceedance of trenching equipment limits where possible.
- Boulder re-position by means of boulder grab system to provide an optimal route for trenching.

NKT will create a target list with boulders of >0.3m that may be obstacles for the trenching tool and cable burial operations, this information shall be collected by NKT during the Pre-lay & UXO survey. Current route engineering has identified 2060 boulders along the RPL centre in a +/- 5m wide corridor in 87 separate areas.

8.1.2 Sand Waves and Mega Ripples

For sections of the cable route where sand waves and mega ripples are found, NKT plan for the following action:

- Verification of area during NKT's pre-lay geophysical survey for change and movement.
- Sand waves or mega ripples are within the limitations of trenching equipment.
- Micro re-route engineering to avoid exceedance of trenching equipment limits where possible.
- Cable burial DOL would be adjusted to ensure specification is achieved at the lowest point / trough without exceeding cable design requirements.

8.2 Planned Schedule

Table 8-1: Offshore Route Preparation Schedule

Activity	Schedule	Est Activity Days
Route Clearance (Boulders)	Q3 2021	75 days
Pre-lay rock placement (crossings)	Q2 2022	5 days
Route Clearance (OOS Cables)	Q2 2022	5 days
PLGR / (Mattress) CP1 2022	Q2 2022	17 days
PLGR / (Mattress) CP2 2023 (Weisdale Voe)	Q1 2023	15 days
PLGR / (Mattress) CP2 2023	Q2 2023	17 days

8.3 Vessels

8.3.1 Vessel Types

Boulder clearance, PLGR operation or Mattress installation would be carried out prior to the cable lay campaigns. An offshore support vessel could be used for offshore works, similar to Figure 8-1. For cable crossing protection using Mattresses NKT plan to use the Cable Lay Vessel NKT Victoria, for pre-lay rock placement vessel types are covered in Section 11.3.

Figure 8-1: Vessel Glomer Worker

For PLGR and nearshore cable protection operations in the more restricted marine area of the Weisdale Voe, a smaller multicat workboat will be utilised, similar to Figure 8-1.

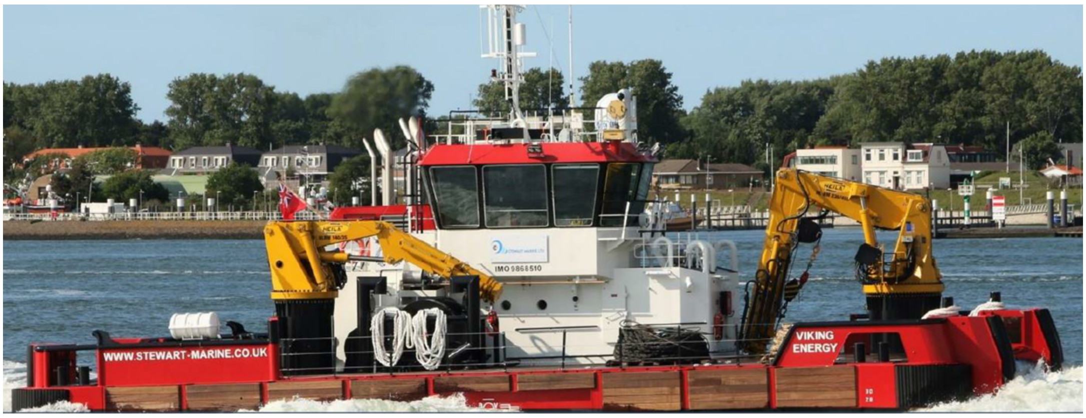


Figure 8-2: Viking Workboat

8.4 Equipment

The following equipment has been identified for use for seabed preparation.

8.4.1 Boulder Clearance Grab

A Tine Grab could be used that attaches to the SMT-ROV tool interface which provides a highly controllable excavating and lifting tool for numerous seabed tasks. Operations are controlled from the vessel by system telemetry, video and cameras on SMT-ROV provide real time feedback for monitoring operations.

The Tine Grab, or Orange Peel Grab could also be used and operated via a vessel crane with Auto Heave Compensation (AHC) and ROV for positioning over the target boulder.

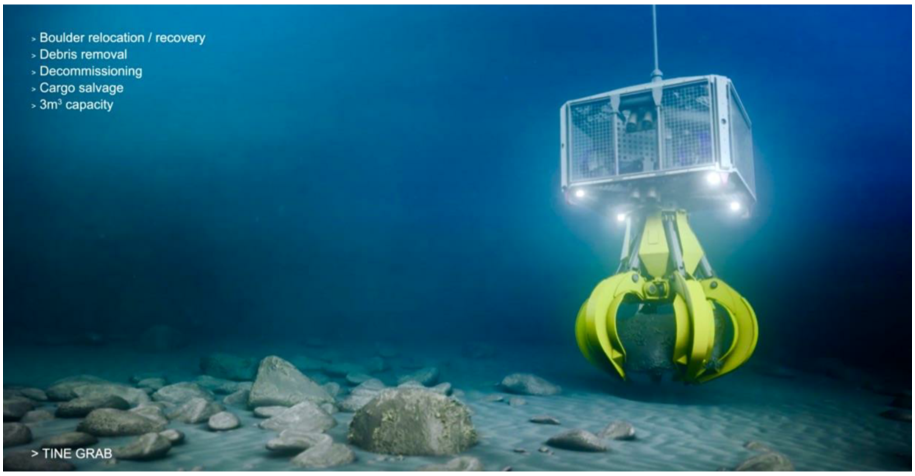


Figure 8-3: Typical Boulder Grab tool

8.4.2 PLGR

PLGR rigging shall be towed behind the OSV to snag any seabed debris that could get entangled in the seabed intervention trenching equipment. Penetration for the grapnel rig shall range from 0.3 to 1.5m for the de-trenching grapnel as shown in Figure 8-4.

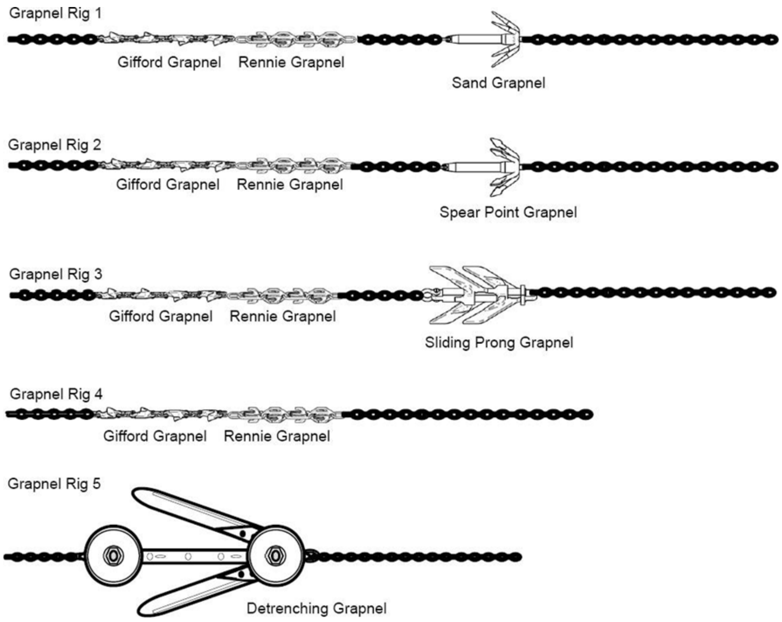


Figure 8-4: Typical Grapnel Configurations

8.5 Construction Method Statement – Summary of Route Clearance

8.5.1 Boulder Removal Operations

For the boulder clearance operations, NKT proposes the use of the Subsea Multi-Tool Remotely Operated Vehicle (SMT-ROV) Crane Launched System, or similar.

The SMT-ROV is a multi-purpose intelligent system for delivering power and positioning to underslung tools.

NKT shall take all the above into consideration when planning the boulder relocation route which shall be positioned off the cable corridor RPL with a lay down tolerance +/- 5m and trencher width for working corridor, such that boulders shall be planned for offset of greater than 15m from the cable route centreline. A boulder listing shall be created with position and re-position co-ordinates, size, shape, with supporting MBES and SSS survey data.

A Tine Grab is lifted overboard and held vertically tethered and not free flying so can be left in the water whilst the vessel moves in to position (vessel speed limited to 0.5-1 knots). Boulders are identified, position confirmed and then the grab collects the boulder and the vessel moves to the release position, where the reposition co-ordinates are recorded. Where there is transit to a new working area, the grab is recovered to deck and secured.

The limitation of this grab is it can only move boulders 2m diameter or less, any “iceberg” boulders that are not fully accessible would not be shifted.

8.5.2 PLGR Operations

Executing a Pre-Lay Grapnel run in advance of the cable installation activity is an international industry standard and recommended by ICPC (International Cable Protection Committee).

For PLGR operations, a single pass grapnel run will be made along the proposed cable route the vessel shall utilise a grapnel that will penetrate up to 1.5m into the seabed subject to seabed conditions. The hook will remove any surface debris which may exist on or just below the seabed.

A PLGR will be conducted in advance of the cable installation to ensure that the cable routes are free of debris, such as any abandoned fishing nets, old wires, ropes and other partially buried objects which could pose a hazard to cable installation. Any known Fibre Optic cables, Pipelines or other structures in the vicinity of the proposed cable route shall be clearly identified in the Project PLGR Procedures.

Grapnels will not be towed closer than 500m from any existing pipelines, offshore structures and fibre optic cables unless permits are in place as per current ICPC recommendations.

On recovery, the grapnel will be cleared, inspected and redeployed. All objects recovered from the grapnels will be photographed and included in the PLGR Report. A 100m overlap will be performed at all recovery points to ensure 100% coverage of the entire planned cable routes.

8.5.3 Debris Disposal

All recovered debris will be transported to NKT’s nominated port for demobilisation and unloaded onto the quayside for disposal. Any hazardous waste recovered will be logged and arrangements made for disposal via appropriately licensed waste handling facilities. The appropriate risk assessment and suitable hazard prevention measures shall be implemented, as detailed in the relevant project procedures, should any hazardous waste be recovered.

Management of debris shall follow the procedures as described in Ref [8] the Marine Construction Environmental Management Plan.

Typical debris envisaged includes old cables and fishing wires, fishing nets, and discarded structural debris associated with construction work.

Additional hazards which include unexploded ordnance, which can possibly entangle in other debris would be mitigated from the UXO survey to As-Low As Reasonable Practical (ALARP) certificate for a safe route.

Any debris of archaeological interest will be reported in accordance with the project specific Archaeological Finds Plan, Ref [9].

8.5.4 OOS Cable Operations

The use of a de-trenching grapnel is a time and cost-effective method for clearing OOS cables that is accepted as an international industry standard and is recommended by the ICPC.

The PLGR grapnels would be recovered where a located OOS cable is within 500m of “In Service” crossing cables or pipelines. The positions of all cables and pipelines shall be confirmed during the pre-lay and UXO survey and a safety distance would be established from that “In Service” crossed asset. Any search for the OOS cables to cut and peel away will always be safely conducted outside the 500m safety zone, as agreed with the asset owner.

During all de-trenching grapnel operations, the vessel shall proceed at a speed that ensures the grapnel maintains penetration into the seabed until the OOS cable is de-trenched.

The OOS cable is then cut using the de-trenching grapnel, or with a ROV and cable ends are attached to the vessel winch to allow for peel back and repositioning outside the minimum corridor width of +/- 15m, shown in the figure as (pale yellow). The cut cable ends will be connected to a clump weight, and position recorded in accordance with ICPC recommendations.

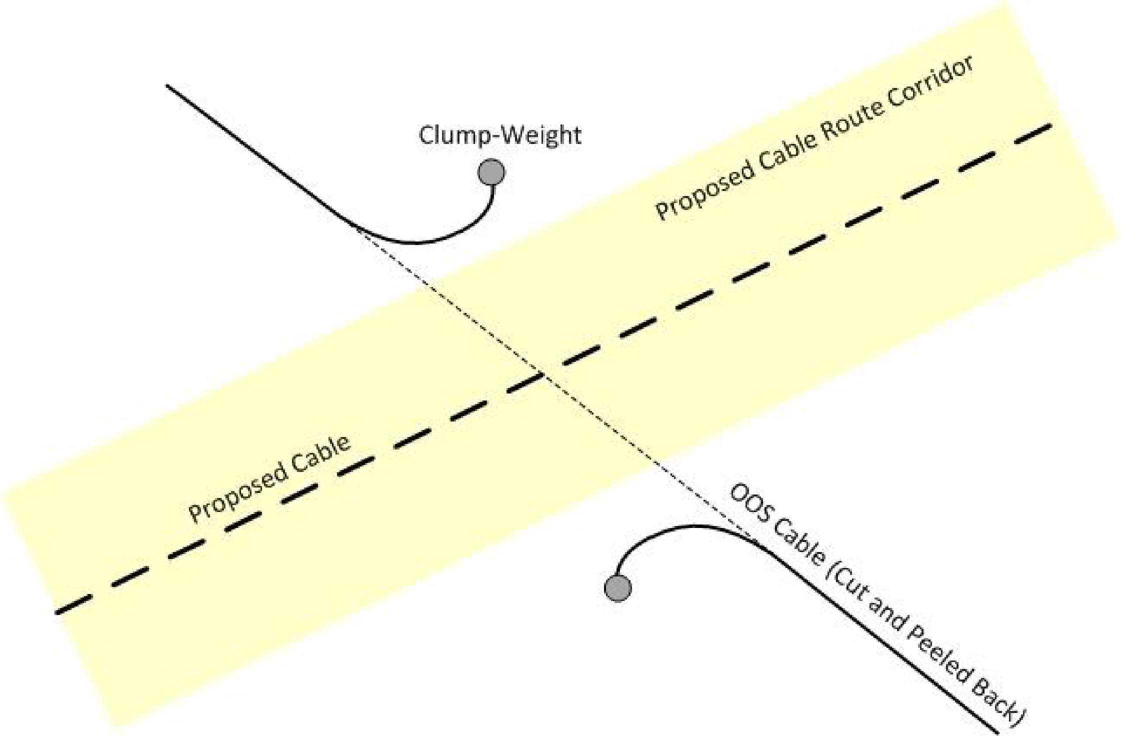


Figure 8-5: Clump Weight Placement

8.5.5 Mattress Installation Operations

Mattress Installation Operations shall be either carried out during route preparation or by NKT Victoria CLV. NKT currently plans for mattress installation over each crossing with the use of the Cable Lay Vessel, just prior to cable installation. The details of each cable crossing protection method is described in Section 4.4 and in the Cable Burial Protection Plan [7].

Once on location the ROV will provide images of the seabed via the cameras, or in very poor visibility conditions, images will be provided via sonar imaging equipment. An as-found survey of the worksite location shall be performed prior to installation.

The Mattresses shall then be lifted by the vessel crane, lowered and orientated into position utilising the supporting ROV sonar imaging equipment and cameras. The mattress will then be lowered to seabed holding the orientation.

The Mattress shall be released from the lifting frame, leaving the mattress in its final position and the frame shall then be recovered to surface.

An as-left survey shall be carried out on completion of tasks at each location.

8.5.6 Rock Bags / Filter Units (Contingency Protection)

Rock Bags / Filter Units may be required to be included as alternative cable protection method. Localised temporary use for either cable pinning for wet stored cable ends or for permanent cable protection shall be confirmed during detailed project engineering.

Rock Bags / Filter Units have a significant advantages over other cable protection / stabilisation methods; such as rock placement and concrete mattresses, in that they can withstand greater currents, be positioned with greater accuracy, reduce the risk of damage to existing assets, and can mould around the shape of the cables more easily than rock placement or mattresses; thus, reducing the possibility of point loading on the HVDC cable bundle.

9 Offshore Works – Cable Lay Operations

9.1 Overview

NKT's cable laying vessel NKT VICTORIA will be used for the installation of the Shetland HVDC and FO cables. NKT shall lay the HVDC Link as bundled HVDC cables together with fibre optic cable. This shall be completed in 3 separate campaigns over the 253km route length, with installation planned for one campaign in 2022 and two campaigns 2023, as detailed in Table 9-1. During the final cable lay campaign two (2) offshore rigid sea joints shall be assembled in cast-iron casings on the CLV and then over boarded as either an in-line joint formation (1st joint) or an omega joint formation (2nd Joint) to complete the HVDC Link.

9.2 Planned Schedule

Table 9-1: Cable Lay Vessel Schedule

Activity	Schedule	Est. Activity Days
Cable Lay Campaign 1 (98km)	June/July 2022	25d
Cable Lay Campaign 2 (57km)	March/April 2023	9d
Cable Lay Campaign 3 (98km)	June/July 2023	33d

9.3 Vessels

9.3.1 NKT VICTORIA

NKT VICTORIA has enhanced Dynamic Positioning (DP3) capabilities with a 7,000T upper turntable capacity and 4,500T lower turntable capacity, in conjunction with a 500T Fiber Optic cable tank, which makes NKT VICTORIA ideal for installing the bundled HVDC & FO cables. The vessel is dedicated to cable installation operations and has been designed to install cables in both shallow and deep waters and the large storage capacity allowing for installation over long distances.

Figure 9-1: CLV NKT Victoria

The vessel complies with the high requirements within the offshore market for cable laying vessels for both the Oil & Gas, Interconnector and Renewable industry.

9.4 Equipment

9.4.1 ROV

The CLV is equipped with two ROVs; Schilling UHD III and a Panther XTP.

- Schilling UHD 250 HP, one of the most advanced, ultra-heavy-duty Work ROV's in the market. This ROV can reach the deepest waters and operate in high currents. The ROV is launched with a dedicated LARS from the ROV hanger starboard side of the CLV.

- SAAB Seaeye Panther XTP, a fully electric Work ROV capable of working in shallow waters, matching NKT Victoria's shallow water capabilities. The ROV can also operate in fragile environments with zero oil pollution risk. The Panther XTP is launched with a dedicated LARS from the ROV hanger portside side of the CLV. However, to optimise the performance of the ROV in shallow water the entire Panther XTP module, including LARS, might be moved to the stern of the vessel.

The typical lay-out for bundled cable laying is shown below.

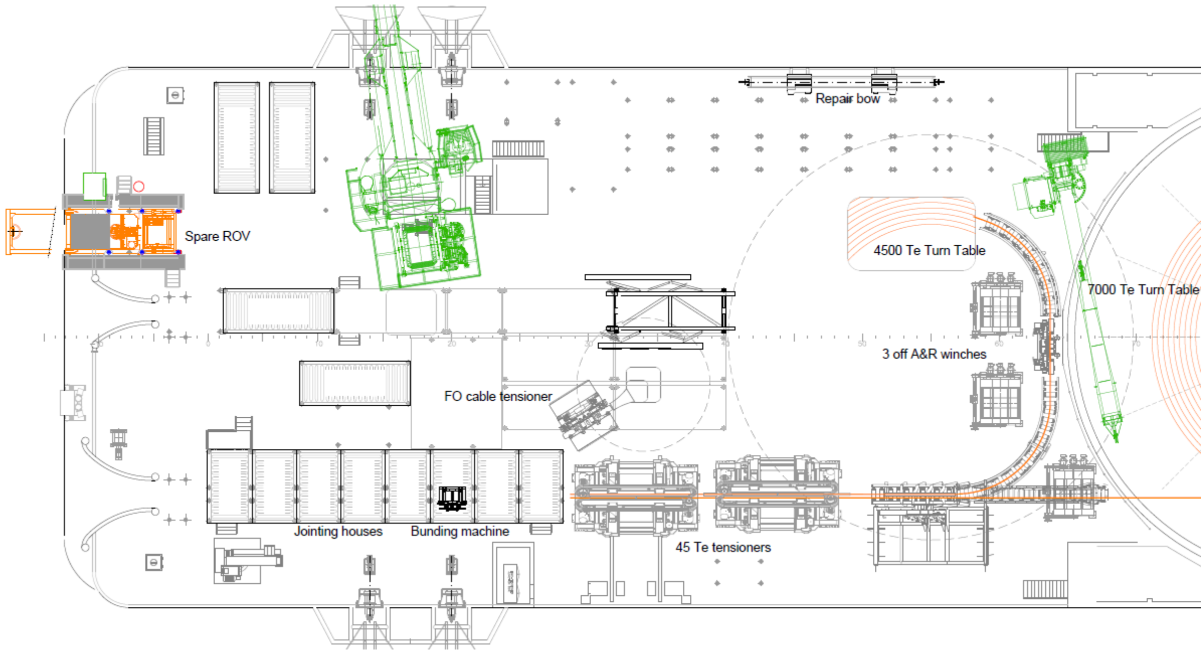


Figure 9-2: Typical deck layout NKT Victoria

9.5 Construction Method Statement – Summary of Cable Lay

9.5.1 Pull-in Operations

Cable Pull-in at Noss Head

A first end direct pull-in is planned through two of the three installed HDD ducts at the Noss Head landfall. The cable pull to the location of the joint bay is assumed for on preliminary assessment, it is expected that the CLV will position from the shoreline close to the duct exit at 22m LAT. Final positioning is subject to detailed engineering.

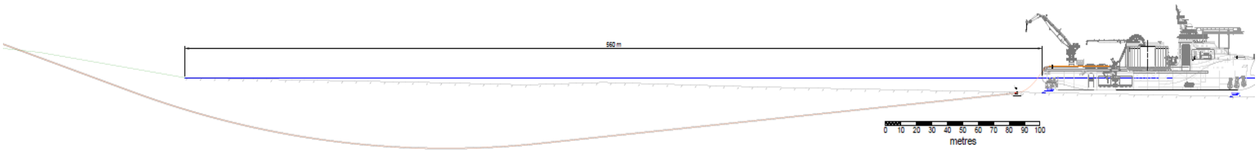


Figure 9-3: Proposed direct pull in through HDD at Noss Head

The Cable Lay Vessel pull-in method to Noss Head is described below. With the NKT shore team in place, the two DC cables are pulled in one by one. The FO cable will be pulled in together with one of the DC cables.

Once the CLV is in position the ROV is deployed. After the HDD cover is removed, the messenger wire and shore winch will be recovered to the vessel with the A&R winch. On the CLV back deck the messenger wire will be disconnected and stored on the CLV, while the shore winch will be connected to the cable end.

Once connected the cable is gradually pulled in by paying in the shore winch, while the HDD entrance is being monitored by the WROV. During the pull in there is continuous radio contact between shore and CLV to communicate pull in tension and pay in speed. When the cable end has reached the transition joint pit, a temporary hang off shall be fitted to the cable.

When the first cable is secured the same operation shall be performed a second time to pull in the other DC cable together with the FO, through a separate HDD duct

Figure 9-4: Typical direct pull in (CM jointing pit at Noss Head depicted)

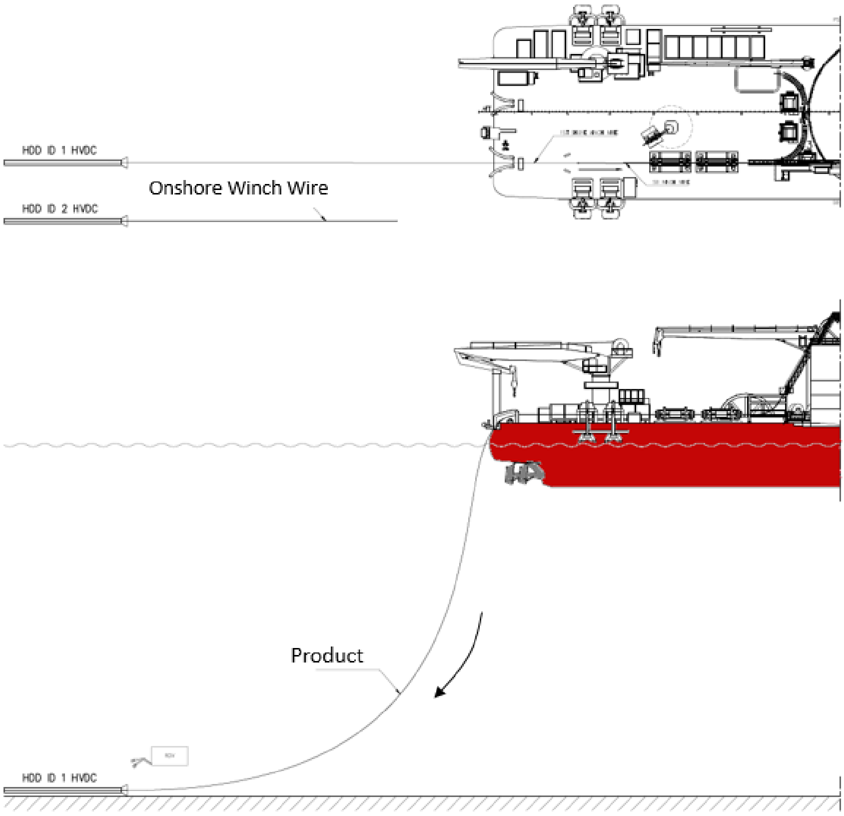


Figure 9-5: Pull in schematization of NKT VICTORIA for two single HDDs

Cable Pull-In at Weisdale Voe

A 1st end direct pull-in operation is planned for the landfall in Weisdale Voe, Shetland. Based on preliminary assessment it is expected that the CLV will position between 12m to 20m LAT during pull-in operations, from where the cable bundle is planned to be pulled in directly in to shore.

The pull-in operation will be performed in a similar manner to Noss Head installation, this time either the cable is pulled in to a PE duct or excavated open trench with cable protection system attached to the cable bundle. Final method is subject to detailed engineering by NKT.

Figure 9-6: Overview of Weisdale Voe

9.5.2 Cable Lay Operations

HVDC Bundle Cable Lay

After the first end pull in has been completed the CLV will start laying the HVDC+FO cables bundled over the vessel stern along the engineered cable route. The engineered cable route will be loaded on the survey screen and the touch down point shall constantly be monitored.

The HVDC cables and FOC will be consolidated aft of the two tensioners. When the cable laying commences the HVDC cables and the FOC will be initiated and during laying the FOC will be bundled together with the HVDC cables.

Once the cables have passed both tensioners the cables will enter the jointing containers. The cables will then be bundled together with the bundling machine positioned in the jointing containers and departure over the chute.

Figure 9-7: Bundling of HVDC cable + FO

Touch down monitoring

Touch down monitoring is performed by one of the two WROV available on NKT VICTORIA. In case of bad visibility, a ROV mounted sonar system (e.g. Gemini) will be utilised. NKT VICTORIA is equipped with two WROVs for redundancy if the primary WROV is on break down.

9.5.3 Cable Crossing Operations

At each HVDC cable crossing as listed in Table 4-4, the cable lay speed shall be slowed and the cable laid across the pre-positioned mattresses or the pre-installed crossing berm, as planned for the Piper to Flotta oil pipeline.

For the crossing of the MPA, described in Section 4.4.3 and Subsea 7 Bundled Tow Route, described in Section 4.4.4, a cable protection system, like Uraduct or Cast-iron shells, shall be assembled on the vessel just prior to cables over boarding the aft chute and then followed with touch down monitoring.

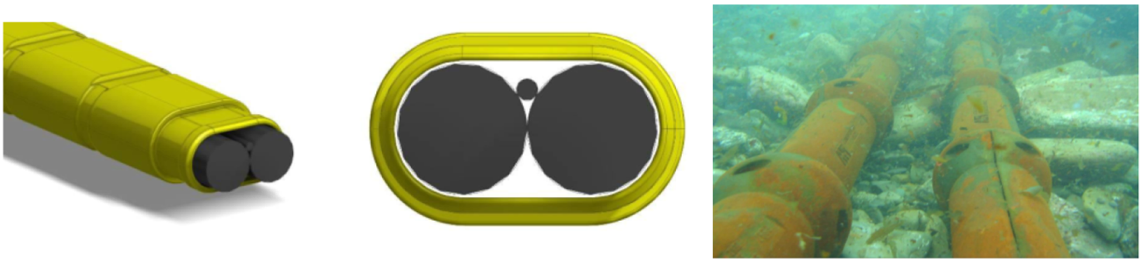


Figure 9-8: CPS - Uraduct and Cast-iron shells

HVDC Cable Bundle In-line Jointing

An In-line cable jointing is proposed at 57km from Weisdale Voe and an omega joint is planned 98km from Noss Head.

Cable jointing involve the following main tasks:

- Survey and recovery of cables to deck and into jointing position.
- Deck preparations.
- Preparation of cable ends.
- Jointing of HV cables and FO cable.
- Bundling of joints.
- Over boarding of joints.

Over boarding of the rigid joints

The rigid stiff joint will be installed with bending restrictors on each side fitted after completion of the joints.

Over boarding of the joints are outline below:

- Rigging is fitted to the joint assembly and connected to the vessel crane. The rigging and how it is attached to the bundled joint assembly is subject to detail engineering. Typical rigging is shown below.

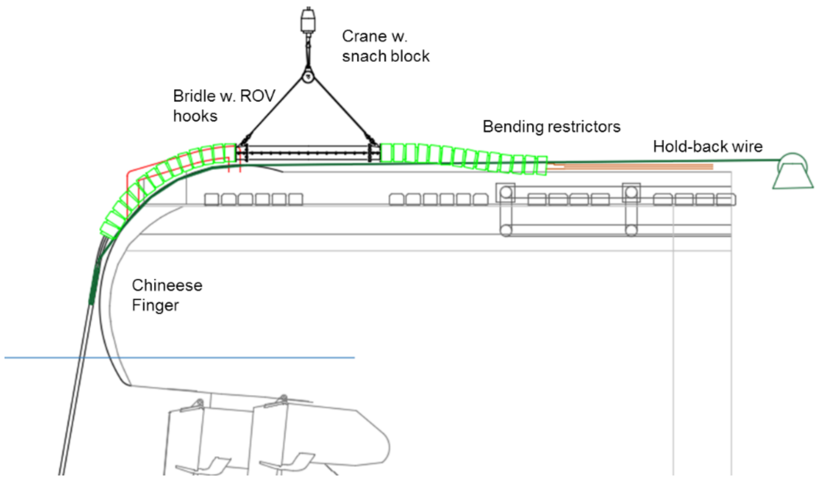


Figure 9-9: HVDC Joints are lifted overboard

- The entire joint assembly passes the chute to hanging vertically, the load is transferred to the tensioners and the lifting bridle and the A&R winch are disconnected by ROV at suitable depth.

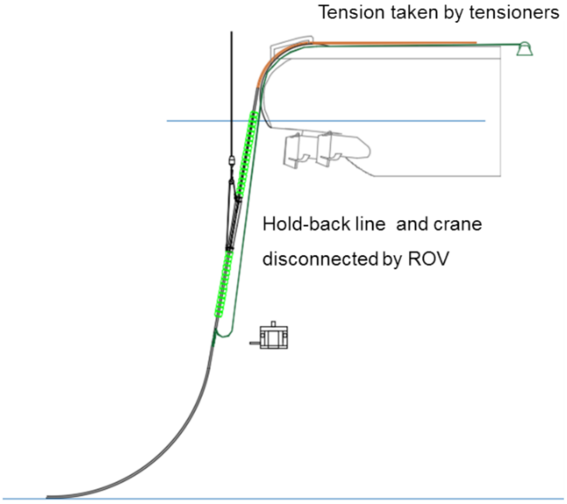


Figure 9-10: Hold-back wire disconnected by ROV

- The bundle and joint assembly is laid on the seabed in one continuous operation and according to parameters derived during detail engineering.

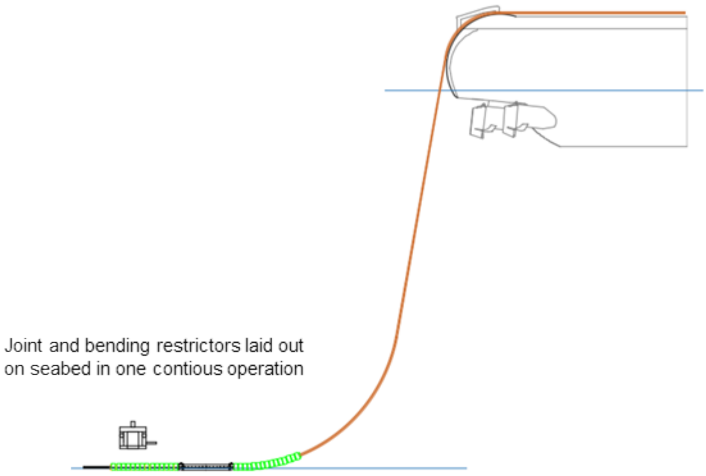


Figure 9-11: Joint being laid out on seabed

- After the joint is positioned on the seabed the ROV will survey the joint assembly and record its position.

10 Offshore Works – Cable Protection – Trenching

10.1 Overview

NKT has planned to use a Trenching Support Vessel (TSV) and jet trenching solution for cable protection for 249km of the cable route that can be trenched. The Cable Burial Risk Assessment [17] feed study has informed SHE Transmission of the required burial specification, which has defined the burial requirements as 1.0m to 1.75m for depth of lowering and 0.15m to 0.6m for depth of cover.

The detail of NKT cable burial protection plan is covered in [7].

The cable shall be trenched into the seabed using suitable trenching tool and method to provide the HVDC cable link with the required depth of lowing and depth of cover as detailed in the cable burial protection plan for the cable route.

10.2 Planned Schedule

Trenching schedule is planned for three (3) separate trenching campaigns to co-inside with the cable lay campaigns and to provide cable protection as early as reasonably practicable based on vessel/equipment availability.

Table 10-1:Trenching Vessel Schedule

Activity	Schedule	Est. Activity Days
CP1 Pre-Trench survey / Trenching / Post Trench survey	July/Sept 2022	60d
CP2 Pre-Trench survey / Trenching / Post Trench survey	April/May 2023	30d
CP3 Pre-Trench survey / Trenching / Post Trench survey	July/Sept 2023	60d

10.3 Vessels

10.3.1 Vessel Types

The Trenching Support Vessel (TSV) is a purpose built Offshore Construction / ROV / Survey vessel specially designed for operation under severe weather conditions with high manoeuvrability and station keeping capabilities.

Figure 10-1: Example - TSV Grand Canyon

10.4 Equipment

10.4.1 Jet Trencher T1200/T1500

T1200/T1500 are configured for post lay burial of submarine cable products to a depth of burial of 3 meters in water depths of up to 3000m. They have become one of the most technically advanced trenching systems available in the global Oil and Gas/Renewable marketplace.

The system will specialise in rapid post-lay burial of submarine installed products, in varying soil strengths up to 100kPa to 150kPa.

Figure 10-2: T1200 recovered to deck

10.4.2 Mechanical Cutting Tool – i-Trencher (currently not planned for)

A mechanical cutting tool could be seen as a project requirement after the pre-lay survey and further detailed engineering on the soil assessment from any new geophysical soil data. If the soil condition is seen to be more suitable to a mechanical cutting tool, to improve depth of lowering and reduce remedial rock, then a tool like I-Trencher could be used.

The i-Trencher trenching system has been designed specifically to trench up to 2m in one pass. It is a track based mechanical unit which has the ability to perform remedial work and can be reconfigured to backfill mode whilst in field. With the reduction in pre-installation works, DSV time and rock dumping requirement, this system will provide a technically efficient trenching solution for soil strength up to 600kPa.

Figure 10-3: i-Trencher (Mechanical Cutter)

10.4.3 Workclass ROV - Triton XLX / Schilling UHD

The Grand Canyon is equipped with Triton XLX Systems or Schilling UHD systems.

A full survey / workclass ROV system will be mobilised for the purposes of performing a pre-trench and post-trench surveys, the ROV will be fitted with sensors and equipment to provide cable tracking system, seabed profile survey (MBES), cameras and video:

10.5 Construction Method Statement – Summary of Trenching

10.5.1 Trenching Overview

From NKT's burial assessment with the trenching contractor jet trenching is a method to be used for the bulk of the works in mainly granular soils and some soft clays sections.

The estimated utilisation based on the data provided is 241.9km [95.79%] with 1st pass jetting and 89.7km [35.5%] with a 2nd pass jetting operation.

Much of the granular soils are very coarse and gravelly and extensive remedial jetting is likely to be required. The burial requirement is favourable with the selected trenching method

Jetting speeds are likely to vary significantly. In most cases the speeds are likely to range between 250m/hr and 350m/hr for both the initial jetting pass and remedial operations.

10.5.2 Ground Model Route Assessment

The ground model route burial assessment has been carried out of the seabed terrain and shallow geology along the cable RPL. Based on this assessment the route can be broken down into the following generalised zones shown in Figure 10-4.

Figure 10-4: Ground Model Route Assessment

Zone	General description	Distribution
1	Variably thick veneer of SILT and CLAY grading to SAND and GRAVEL at depth overlying bedrock, which occasionally outcrops	Weisdale Voe, KP0.0 to KP6.0
2	Thin to absent accumulations of SILT and SAND within depressions between well-defined outcrops of bedrock which occur as a series of east to west ridges	Seaward end of Weisdale Voe, KP6.0 to KP8.0
3	Thick superficial layer comprising a variable thickness of SAND over SILT and soft silty sandy/gravelly CLAY. The underlying fine grained soils outcrop locally and very occasionally the bedrock	Outer Voe, KP8.0 to KP38
4	Thin but fairly consistent veneer of coarse SAND and GRAVEL overlying bedrock interpreted to comprise sandstone and siltstone, which outcrop occasionally at the seabed and are identified by boulder fields.	North Atlantic, KP38 to KP94
5	Very thin occasionally absent SAND/GRAVEL veneer over bedrock which frequently outcrops at the seabed displaying a rugged topography interpreted as a boulder field	North Sea, KP94 to KP158
6	Thicker more consistent layer of sandy GRAVEL and SAND grading to clay in places overlying bedrock	North Sea, KP158 to KP190
7	Variably thick veneer of SAND and GRAVEL over CLAY/SAND/GRAVEL (Glacial Till) and bedrock (Chalk, Flint and Marl) which subcrops locally at the seabed forming localised highs with associated boulder fields.	North Sea, KP190 to KP231
8	Thicker layer of surficial SAND overlying CLAY and bedrock at depth	Approach to Noss Head, KP231 to KP246
9	Thin to absent SAND veneer over BEDROCK (Chalk/Flint/Marl; then Sandstone)	Landfall at Noss Head, KP246 to KP252

10.5.3 Jetting Tool

The below pictures show the main jetting tooling, directly attached to the HP water pumps. The lowering mechanism allows the tool to be lowered to depth keeping a constant jetting angle.

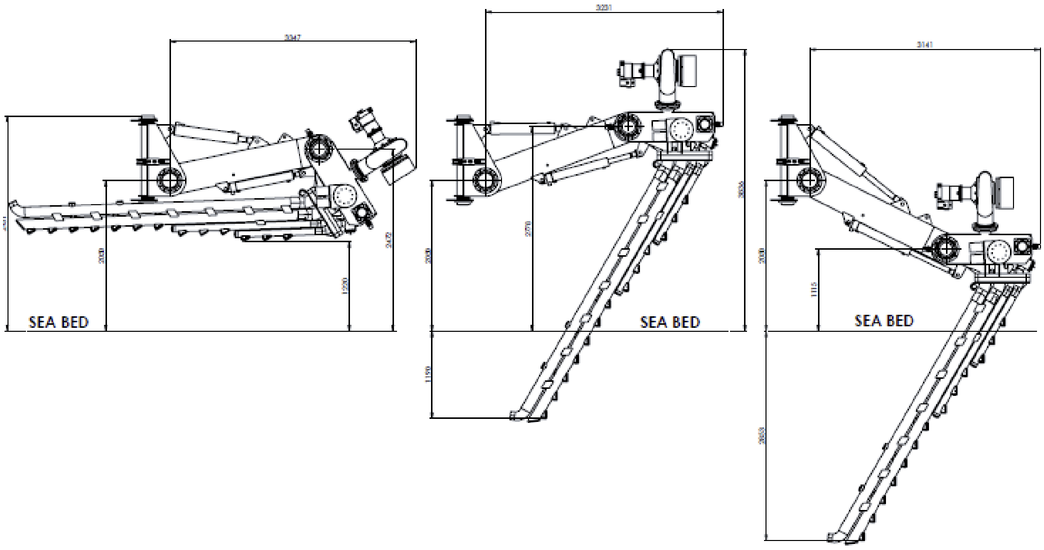


Figure 10-5: Jetting Sword

The burial depth control tolerances of the trenching vehicle are broken down into a number of key functions:

- The position of the bottom of the jetting arms relative to the chassis of the vehicle is sensed to a high accuracy.
- During every aspect of the jetting operation, the soil cutting nozzles remain at the optimum geometric angle to create the optimum trench around the product. In this way the trench depth achieved corresponds to the tool depth selected by the operator in accordance with the approved procedures.

Depending on the required specification for the soil conditions to be encountered the trencher can be operated in either backwash, described below, or eduction where cohesive soils are extracted and not backfilled, and in backfill mode, where trench walls are collapsed to provide additional depth of cover. Eduction and backfill are not envisaged to be required for trenching from the initial burial assessment analysis.

10.5.4 Backwash Mode

Backwash mode uses rearward facing nozzles at the bottom of the trench to inject low pressure high flow water back along the trench as detailed in the diagram below Figure 10-6. The backwash function is to maintain jetted soils in suspension long enough to allow the product to lower through the fluidized soil to bottom of the cut trench, thus achieving the required depth of lowering specification.

Backwash pressures are set to optimise the required fluidisation to allow the HVDC cable bundle to be lowered to the design depth of lowering, and settlement of the fluidised material occurs shortly after to return the soil depth of cover. If the trenching vehicle speed slows or comes to a stop backwash is switched off and forward jets pressures are adjusted or switched off to assess the nature of the trenching stop.

Backwash Principle (Sands)

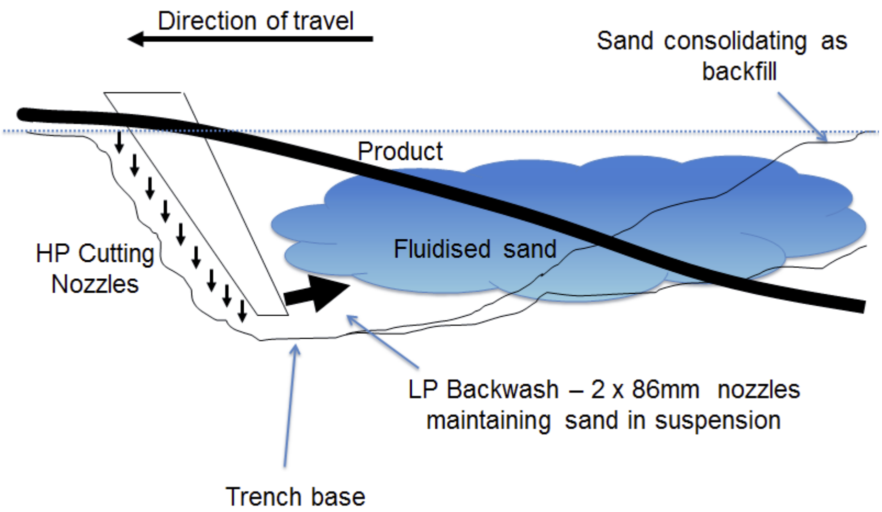


Figure 10-6: Jetting Principles

10.5.5 Pre-Trench Survey

A pre-trench (MBES and TSS) survey shall demonstrate whether the route is sufficiently clear and to optimize the trenching tool set-up for cable lowering and protection.

10.5.6 Achievable Trench Depth

Achievable trench depth and trenching system's rate of progress may be affected by local seabed features including slopes and uneven seabed, which are always possible. Free spans that are created by uneven seafloors may restrict the passage of the jet trenching machine in extreme areas and this may limit the remediation that can be achieved for those areas.

10.5.7 Measurement / Monitoring of Depth of Lowering / Cover

The trencher can be fitted with a TSS 440/350 pipe tracker profilers to enable operators to monitor position of the cable during trenching operations.

To accurately measure the cable position during post trench survey operations for DOL and DOC values after each trenching pass, a fully calibrated WROV and TSS sensors or Pangeo Sub-Bottom Imager (SBI) would be used.

The Figure 10-7 below, provides an idea of how the on-board electronics are utilized to gather the data.

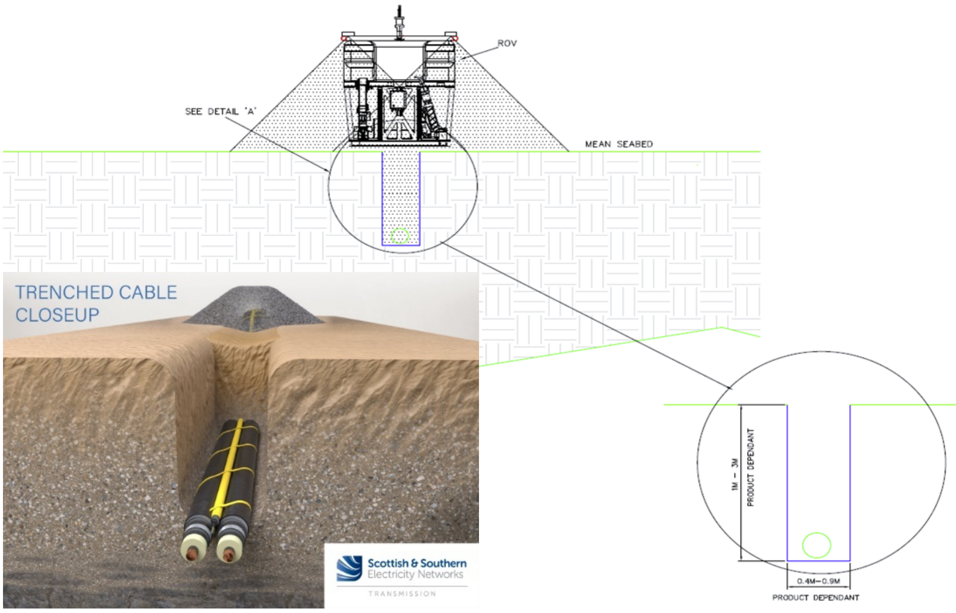


Figure 10-7: Trenching Tool DOL Measurement Principle

10.5.8 As-Trenched Survey

The post-trench survey shall use either the TSS440/350 cable tracking system or a Pangeo SBI tracking system to cover the as-trenched survey for the cable route to record and measure the cable depth of lowering and cable depth of cover.

The survey will comprise one pass along the entire length of the cable. Where the survey is stopped and restarted a 50m overlap should be undertaken to ensure coverage and provide enough data to allow processing between data files. MBES swath shall be set to ensure undisturbed virgin seabed level is observed.

A survey chart will be provided with a panel depicting the burial results along the entire length of the product, this chart will support the decision for locations identified for remedial rock protection works or locations for further remedial jet trenching to further improved depth of lowering and mitigate the need for rock protection, with a further post trench survey.

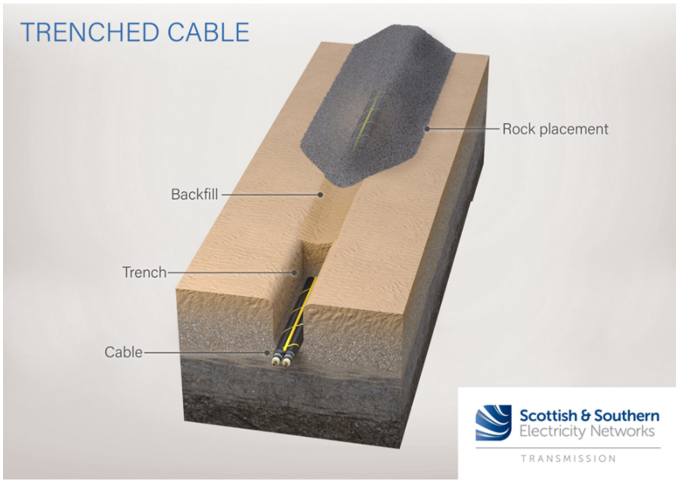


Figure 10-8: Overview image of a trenched cable

11 Offshore Works – Cable Protection – Rock Placement

11.1 Overview

Planned rock placement are areas identified for pre-lay crossing protection, such as the Flotta to Piper oil pipe crossing and other cable crossing, where rock is placed over the HVDC cable bundle and mattress protection, or where the cable is laid over bedrock and assessed route sections that cannot be trenched.

Remedial rock protection are sections of the cable route that have been identified for lower confidence to achieve the specified depth of lowering and depth of cover and is assessed as not being sufficient to protect the HVDC Link, by means of trenching.

Where the cable cannot be trenched, or the required depth of lowering cannot be achieved, rock berms are placed to protect the cable from damage and from the natural and anthropogenic threats, as shown Figure 11-1. The rock berm designs that would be used are detailed in NKT's Cable Burial Protection Plan [7].

Rock placement specification for the minimum depth of cover for the cable protection is a minimum 0.6m to 1.0m 1-5inch rock, which NKT uses as an input value for the cable protection engineering design requirements. The rock size, berm length and rock volume may vary for the nearshore locations to account for local conditions informed by metocean analysis to provide a stable rock berm condition.

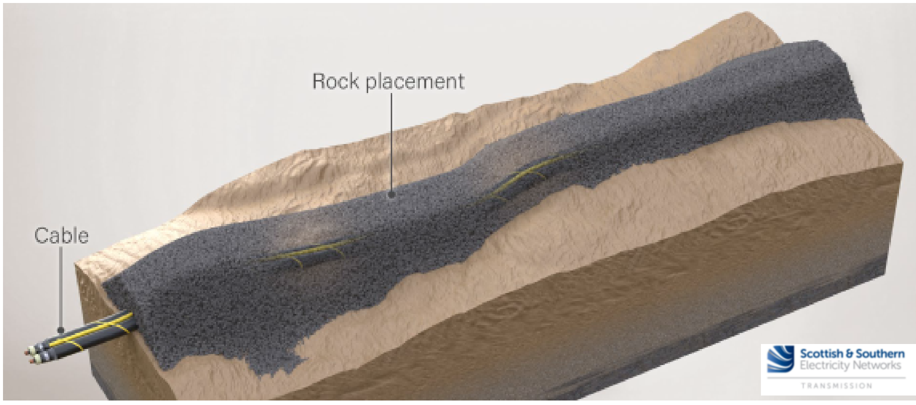


Figure 11-1: Schematic of a surface laid cable with rock placement

NKT has assessed the cable route for the locations of planned rock placement and those locations where remedial rock placement is required. These quantities are according to the trenching contractor's confidence level assessed in the trenching burial assessment analysis.

NKT then use this input with the required berm designs as shown in **Error! Reference source not found.** to estimate the total rock volume for planned and remedial works and have estimated a Total sum of 402,177 Metric Tonnes (MT), inclusive of 20% losses and overburden tolerance of 0.3m, as detailed in Table 11-1. The sum of the Total Licensed tonnages are 533,065MT

Data gained from the post-trench geophysical survey of the final cable route position will be used to revise first the trenching burial assessment matrix, to identify trenching confidence and where remedial rock would be required. Then NKT shall update the rock matrix estimate quantities on materials. Once cable trenching has been completed, the post trench survey results shall inform and allow NKT to update the rock matrix to design quantities, which would contain the actual rock locations and rock volumes required for remedial cable protection.

Table 11-1: Table of Estimated Rock Tonnages

NKT Summary of Estimated Rock Tonnages	
402,177	Estimated Total Rock tonnage (MT) all Protection Works, inclusive of estimated losses 20% and overburden tolerance 0.3m
185,080	Inside 12nm - Estimated Total Rock tonnage (MT) all Protection Works, inclusive of estimated losses 20% and overburden tolerance 0.3m (Noss Head has 20% loss and average tolerance which is material dependent, as design is not yet finalized)
217,097	Outside 12nm - Estimated Total Rock tonnage (MT) all Protection Works, inclusive of estimated losses 20% and overburden tolerance 0.3m

Marine Licence Tonnages	
287,975	MT within 12nm zones
245,090	MT offshore

NKT Summary of Estimated Rock Lengths (m)	
90,915m	Estimated Total Length of Rock Berms
45,075m	Inside 12nm - Estimated Total Length of Rock Berms
45,840m	Outside 12nm - Estimated Total Length of Rock Berms

Note to Table 11-1: Ongoing engineering during the project lifecycle shall revise the quantities of material detailed within this table.

11.2 Planned Schedule

Rock placement schedule is planned for four (4) separate campaigns as detailed in Table 11-2 to occur after each trenching campaign to provide cable protection as early as reasonably practicable and release the Guard Vessel from cable route protection duties.

Table 11-2: Rock Placement Schedule

Activity	Schedule	Est. Activity Days
Pre-lay rock Pre-survey / Rock Placement / Post-survey / Reload	Oct/Nov 2022	2d
CP1 Pre-survey / Rock Placement / Post-survey / Reload	Oct/Nov 2022	40d
CP2 Pre-survey / Rock Placement / Post-survey / Reload	May/Jun 2023	15d
CP3 Pre-survey / Rock Placement / Post-survey / Reload	Sep/Nov 2023	45d

11.3 Vessels

11.3.1 Vessel Types

Rock placement will be carried out by a specialist rock installation contractor using a DP2 Fall Pipe Vessel (DPFPV), similar types to that shown below in Figure 11-2. Nearshore cable protection with rock may require the use of a barge and crane or backhoe excavator to work in the shallow water depths, where a DPFPV would not be suitable.

Figure 11-2: DP Fall Pipe rock placement vessels

11.4 Equipment

The Fall Pipe consists of steel and HDPE pipe sections, allowing the length of the pipe to be adapted to the water depth. The pipe sections are stored in the Stone Dumping Unit (SDU), which is located in the centre part of the vessel. This unit also contains a transport system for the pipe sections and auxiliary equipment for the pipe (dis)assembly. Furthermore, the SDU also contains hydraulic engines and winches for the suspension of the Fall Pipe and Fall Pipe Remote Operated Vehicle (FPROV).

The FPROV is actively heave compensated, which provides a stable survey platform essential for the quality of data gathered by the survey sensors installed on the FPROV. Which is used for the accuracy of rock placement.

The FPROV will be used for pre-, intermediate- and post-surveys, but also to position the fall pipe at the correct location.

The benefits of a Fall Pipe system are:

- No losses of fine material due to the closed system and therefore no creation of undesired turbidity.
- High production without generating uncontrolled, high flow rates at discharge end of Classic Fall Pipe.
- Performance of the works with a DP2 class vessel very close to already installed pipelines, structures, such as ducts.
- Accurate placement of rock to prevent any rock in possible exclusion zones.
- Controlled rock placement through Fall Pipe to ensure that no damage occurs to the crossed cables or pipeline and any anodes attached to pipeline.
- Installation method which ensures that segregation of the rock material loaded into in the fall pipe, were various grades of rock are used, during installation is prevented.

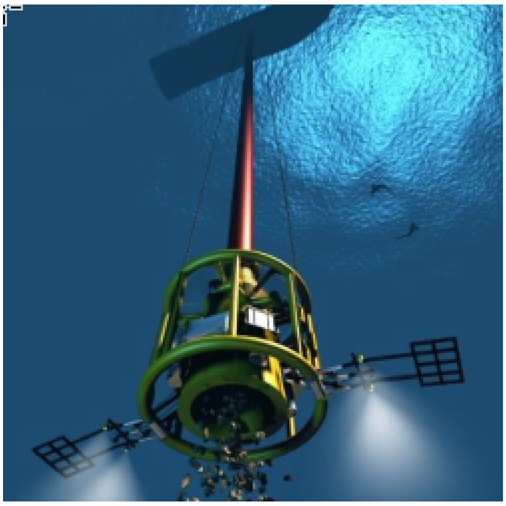


Figure 11-3 Closed Fall Pipe System with FPROV

11.5 Construction Method Statement – Summary for Rock Placement

11.5.1 Rock Characteristics

Only crushed fresh and un-weathered rock will be used. All rock shall be of sound origin, chemically stable, strong, hard, durable, and of limited porosity.

Furthermore, all rock shall be free of adhering coatings, clay lumps, coal/coal residue, contamination from hazardous materials (hazardous being a substance that can cause harm to the environment or living organisms) and organic materials.

11.5.2 Rock Material Testing and Inspection

Quality control (QC) testing and inspection is intended at the investigation / selection stage of the supply followed by regular QC testing and inspection during production and transport. All testing will be conducted by a certified independent instance. EN 13883-1:2013 is a widely used standard recognized by several countries for quality control of the rock material used in construction works both offshore and onshore. It defines some of the more standard aggregates and requirements mentioned in 11.5.1 are also to be found in this norm.

In accordance with EN 13883-2:2019, samples for testing of the mechanical properties are selected from the blasted rock. They will be marked, documented and reported.

11.5.3 Rock Installation Material

The rock berms are to be installed shall be stable under the governing hydraulic conditions. For the nearshore location at Noss Head from the HDD duct exits, given the relatively shallow water depths and potentially severe wave conditions, large rock grading would be required as shown in Table 11-3.

The minimum design specification rock materials for the Works are to have the following characteristics:

Type: Freshly crushed rock, Granite/Gneiss.

For rock material used as protection for the crossings and trenching remedial work:

Rock grading: 22/125mm (1-5")

Specific density: Approximately 2.65 MT/m^3.

Rock will originate from the Norwegian quarries.

For nearshore berm at Noss Head the following rock gradings have been identified, in Table 11-3, which can be used as light grading rock armour layer, the definitions of gradings follow the European Standard EN13383:

Table 11-3: Rock grading for Noss Head

Material Density	1:3 Side slope berm	1:4 Side slope berm
2650 kg/m^3	LMA[1]$_{60/300}$	LMA$_{40/200}$
3100 kg/m^3	LMA$_{40/200}$	LMA$_{10/60}$
3100kg/ m^3	HMA[2]$_{60/300}$	

Note:

1. LMA 60/300 means Light Mass Aggregate grading 60kg to 300kg.

2. HMA means High Mass Aggregate

Filter layer for the nearshore berm will be 22/125mm (1-5”)

If from detailed design engineering identifies high density rock, then gabbronorite rock type could also be used.

Rock berm design are detailed in NKTs Cable Burial Protection Plan [7]. Example figures of the berm designs shown below:

- **Error! Reference source not found.**. Design is based on an unprotected cable laying on the seabed with 0.6m depth of cover over the HVDC Link.

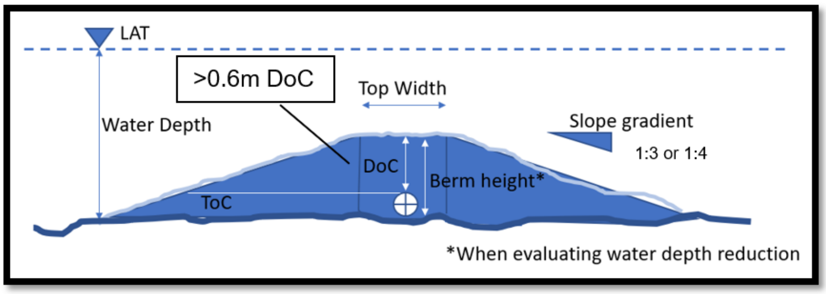


Figure 11.4: Rock Berm Design for Cable on Seabed (Not to Scale)

- Figure 11.5 Design is based on a trenched cable that requires post lay rock protection where the rock berm height is adjusted to provide the required protection of 0.6m depth of cover.

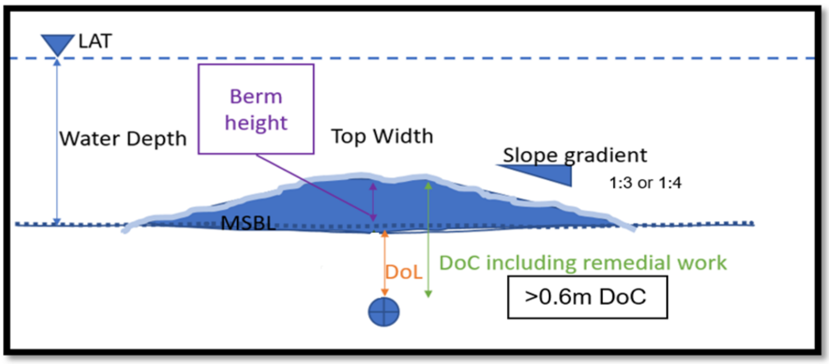


Figure 11.5: Remedial Rock Berm Design (Not to Scale)

- Figure 11.6 Design is based on the additional rock protection required at Noss Head with a filter layer and rock armour with berm. This berm designs for rock grading and berm slopes is proceeding with detailed rock berm stability engineering for the recorded metocean forces at this location.

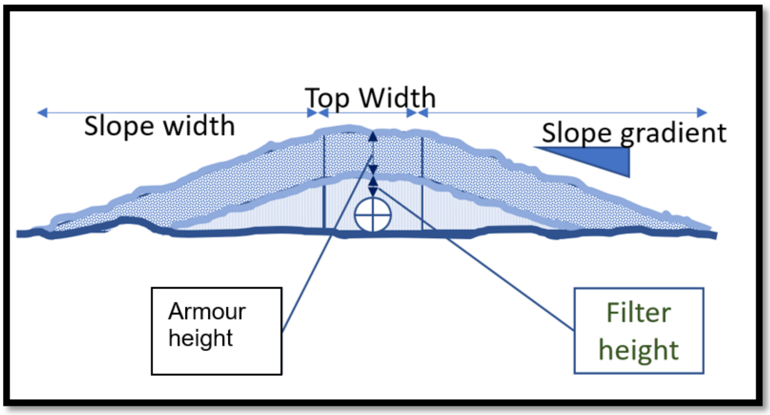


Figure 11.6: Noss Head Nearshore Berm Design Profile (Not to Scale)

11.5.4 Execution of Rock Placement

Rock placement works consists of the execution of a typical rock placement cycle/round trip. For this Shetland HVDC Link Project, the cycle will be executed several times for each campaign as detailed in Table 11-2 and last for 6-8 days per round trip from Norway for loading rock to the HVDC Link worksite. Each campaign will comprise of the following activities:

- Mobilisation & Loading
- Transit to Site
- Launch fallpipe & ROV
- Pre-Survey
- Rock Placement
- Intermediate Survey

- Rock Placement
- Post Survey
- Transit to quarry and reload

12 Offshore works – Cable Protection – Guard Vessels

12.1 Overview

Guard vessels will be deployed to guard the HVDC Link cable bundle from cable lay to the completion of burial and protection of the HVDC Link, or marine other works, where deemed applicable. Guard vessels will be deployed at an approximate spacing of approximately 10-20km, based on risk and the prevalence of other activities

Guard vessel information and vessel route coordination shall also be provided to SHE Transmission Fishing Liaison Officer, as with all other planned construction vessel operations, in line with the SHE Transmission Communications Plan [13] and Fishing Liaison Mitigation Action Plan [14].

12.2 Planned Schedule

Guard vessels are planned with a staggered mobilisation to start just prior to the 1st cable pull-in activity in June 2022 at Noss Head to completion of the accepted cable protection to release each guard vessel as sections are completed, when the accepted condition for cable protection is achieved in Q4 2023.

12.3 Construction Method Statement - Summary

Guard vessels shall be managed by NKT's appointed guard vessel manager working with the Fishing Liaison Officer (FLO).

Guard vessels shall be distributed along the cable route which shall monitor and notify marine traffic approaching of construction works. Vessel monitoring software and visual tracking is used through 24hr / 7day operation to warn, monitor and record marine traffic crossing the unprotected HVDC cable route, until acceptable protection is in place.

Each guard vessel shall be clearly marked and highly visible "GUARD" signs on each side of the vessel.

When each guard vessel requires to port call for fuel, crew change etc. Then that vessel will be replaced by another. This exchange shall be on site and in such a way that the location is never unguarded.

They shall be equipped with as a minimum, Differential Global Positioning System (DGPS), VHF, satellite and mobile telephone systems which are capable of sending the Daily Progress Report (DPR). Each shall be equipped with at least one 3cm Band Radar set; this is to have Automatic Radar Plotting Aid (ARPA) facilities for multiple target acquisition and tracking of marine vessels

Each vessel shall carry a full set of in date flares, plus maroons for attracting attention. The maroons will be the preferred flare to use when attempting to make contact with a vessel approaching the protected location and not responding to VHF calls.

13 Offshore Works – As Built Design Data

Following the completion of the different installation activities, NKT will compile an As-Built report of the construction works, part of which is the as-built drawings, imagery and video evidence that the cable has been safely installed.

The core to this report is the route survey, carried out during campaign, to confirm the cable position with DOL and DOC achieved. This information will be used as the baseline for subsequent surveys and to identify any change in cable protection and surrounding seabed, whether it be cable or rock placement settlement or cable exposure through scour.

14 Marine Installation Footprint

The marine installation footprint for the HVDC Link cable construction activities is detailed in the Cable Burial Protection Plan [7].

The Marine Consents installation corridor which has been applied for the Shetland HVDC Link is a 200m wide (the route centreline +/-100m). The HVDC Link construction works would only require a small part of this licensed corridor width (circa +/- 25m) to install and protect the HVDC Link cable bundle.

15 Vessel Management Plan - Summary

Project vessels and marine works activities shall be managed by the NKTs Project Installation Manager with notification to the SHET then onwards to regulator, marine authorities and the FLO, as to when project marine activities shall start and end.

Details of NKT Vessel Management Plan are contained in reference [5].

Details of the pollution protection measures are described in reference [12].

Notice to Mariners shall be issued as described in 15.1. to pre-warn other marine users as to when and what construction works shall be carried out within the HVDC Link worksite. Communication shall be as described in the Communication Plan in reference [13] and the Fishing Liaison Mitigation Action Plan in reference [15].

The project marine activities are planned to occur in a sequence to minimise simultaneous operations, which are expected to occur for nearshore cable pull-in operations. The Offshore Construction Manager, appointed by NKT, will coordinate for the marine activities between the onshore crew and the offshore crew and vessels. When Simultaneous Operations (SIMOPS) occur, for instance, when in working in the restricted movement area of the Weisdale Voe, NKT shall ensure local Stakeholders are well informed of operations and then their planned movements are known.

As the HVDC Link cable bundle is installed then cable protection using guard vessels would start for the route corridor. This shall be managed by the appointed guard vessels management service with 24/7 operations.

Marine co-ordination between the offshore construction vessels and guard vessel management shall be via NKTs offshore representative, who shall keep the guard vessel, manager, SHE Transmission representative updated on progress and when vessels shall demobilise from worksite.

All offshore works and events shall be captured in Daily Progress Report (DPR) issued by the Offshore Construction Manager (OCM) or Vessel Captain daily, with the supporting project daily calls to the NKTs Project Installation Manager and the SHET s Offshore Project Manager.

If any incident or emergency should occur, then the NKT Emergency Response Plan shall be activated following the 30-minute notification rule to key personnel and authorities. All vessels shall conduct Emergency response drill within 24h from leaving port.

15.1 Notification to Mariners

Marine traffic and fishing vessel activity has been recorded in both summer and winter periods from Oct 2018 to Oct 2020 along the entirety of the installation corridor. NKTs has an awareness of the volume and type of marine vessel activity at given locations along the Shetland HVDC Link cable route to be used for planning, design and marine traffic management.

It is expected that the control measures such as promulgation of information (including Kingfisher Bulletins and Notice to Mariners) as well as the NKTs planning for guard vessels, will ensure marine users are aware of the activities and able to make adjustments to their activities.

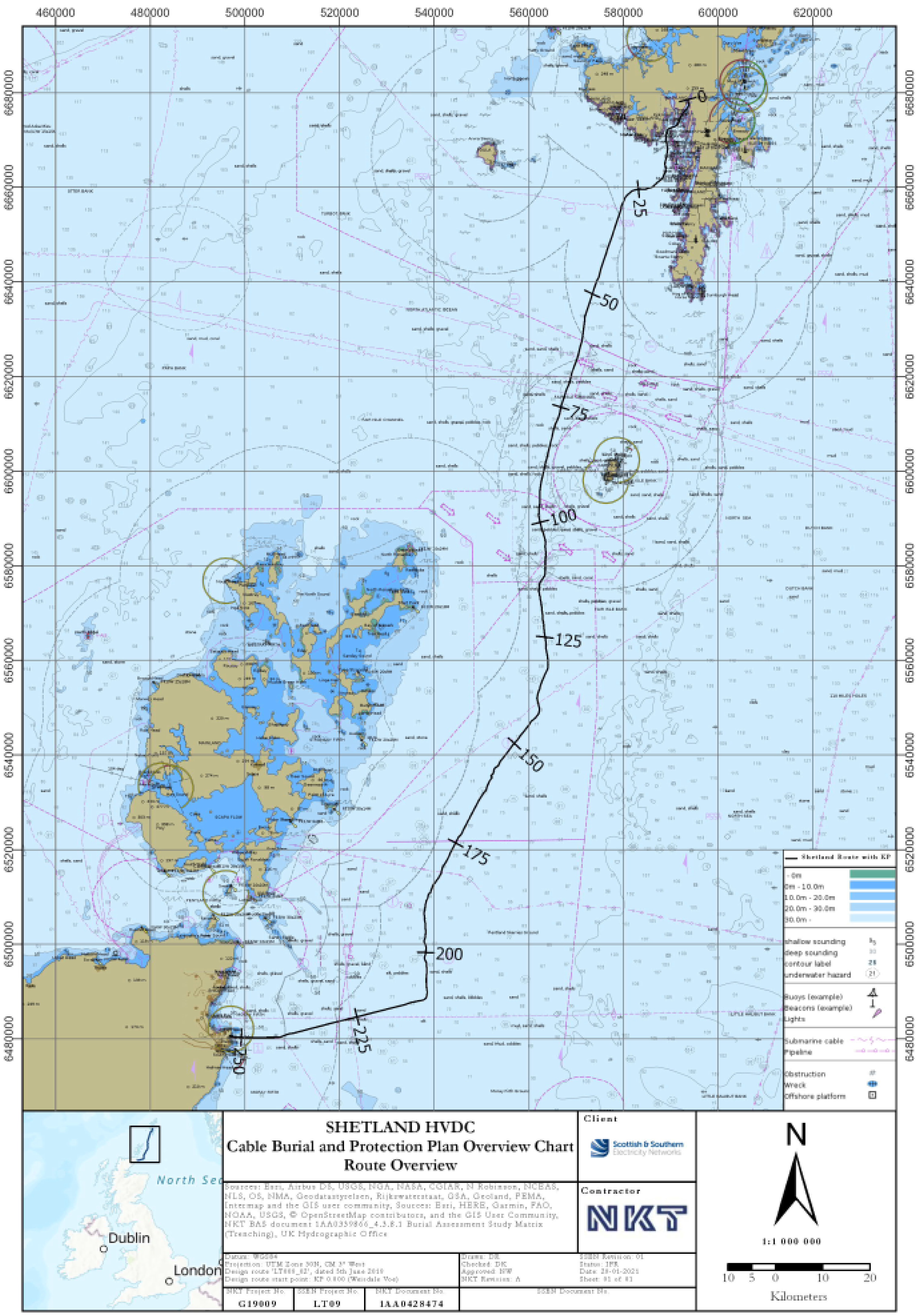
The expect frequency of disruption to other marine traffic is considered to be Reasonably Probable, and with communication, monitoring and control though the project organisation, and the use of guard vessels, these actions are anticipated to minimise the impact to other marine users during the period from May 2021 to December 2023 for the planned construction works.

16 List of Appendices

Appendix 1 – Shetland CBPP Overview Chart (1AA0428474)

Appendix 2 – Schedule of Planned Offshore Works

Appendix A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underwater hazard
Buoys (example)
Beacons (example)
Lights
Submarine cable
Pipeline
Obstruction
Wreck
Offshore platform
North Sea
Dublin
London
SHETLAND HVDC
Cable Burial and Protection Plan Overview Chart
Route Overview
Client
Scottish & Southern Electricity Networks
Contractor
NKT
Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, NKT BAS document 1AA0359866_4.3.8.1 Burial Assessment Study Matrix (Trenching), UK Hydrographic Office
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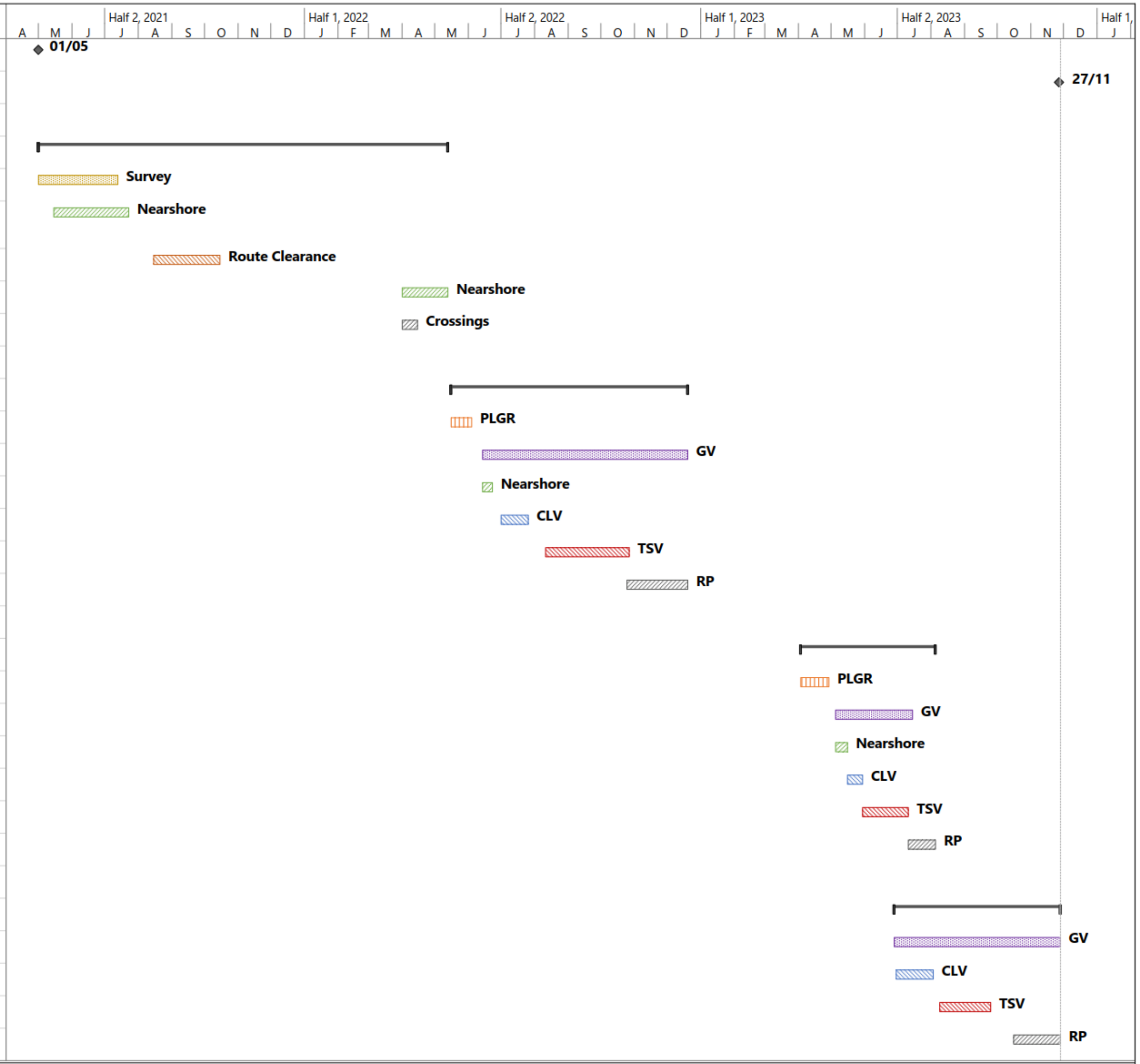
Appendix B

ID	Task Name	Duration
1	Start of Planned Marine Works	0 days
2	End of Planned Marine Works	0 days
3		
4	Marine Preparation Works	272 days
5	Pre-Lay & UXO Survey	53 days
6	Noss Head HDD Nearshore Works (circa 30d to occur during)	50 days
7	Route Clearance (Boulders)	45 days
8	Weisdale Voe Nearshore Works	30 days
9	Pre-Lay Crossings Rock Placement	10 days
10		
11	CP1 Marine Works (KP253 to KP155)	156 days
12	CP1 PLGR	15 days
13	CP1 Guard Vessels	135 days
14	Noss Head HDD Nearshore Works	7 days
15	CP1 Pull-in & Cable Lay	17 days
16	CP1 Cable Burial (Jet Trenching)	55 days
17	CP1 Remedial Rock Placement	40 days
18		
19	CP2 Marine Works (KP0 to KP57)	91 days
20	CP2 & CP3 PLGR	20 days
21	CP2 Guard Vessels	51 days
22	Weisdale Voe Nearshore Works	7 days
23	CP2 Pull-in & Cable Lay	10 days
24	CP2 Cable Burial (Jet Trenching)	30 days
25	CP2 Remedial Rock Placement	20 days
26		
27	CP3 Marine Works (KP57 to KP155)	111 days
28	CP3 Guard Vessels	111 days
29	CP3 Cable Lay & Jointing	25 days
30	CP3 Cable Burial (Jet Trenching)	34 days
31	CP3 Remedial Rock Placement	31 days



Page 1

Table of Modifications

Rev.	Date	Prepared by	Description
A	2020-12-18	Walker, Nigel	First issue of document
B	2021-01-28	Walker, Nigel	Second issue of document
C	2021-02-24	Walker, Nigel	Third issue of document
D	2021-03-10	Walker, Nigel	Forth issue of document