EGL2 Marine Scheme - Landfall Horizontal Directional Drilling (HDD) Method Statement - Scotland

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Acronyms and Abbreviations

AToN	Aid to Navigation
CBPP	Cable Burial Protection Plan
CEFAS	Centre for Environment, Fisheries, and Aquaculture Science
CEMP	Construction Environmental Management Plan
CFE	Controlled Flow Excavation
CTV	Crew Transfer Vessel
DHT	Down-Hole Tool
EAR	Environmental Appraisal Report
EGL2	Eastern Green Link 2
ERP	Emergency Response Plan
HDD	Horizontal Directional Drilling
HDI	Horizontal Drilling International
HVDC	High Voltage Direct Current
JV	Joint Venture
LARS	Launch and Recovery System
LAT	Lowest Astronomical Tide
LCM	Lost Circulation Material
m	Metres
mm	Millimetres
MBES	Multibeam Echo Sounder
MCA	Maritime and Coastguard Agency
MD-LOT	Marine Directorate Licensing and Operations Team
MFE	Mass Flow Excavator
MHWS	Mean High Water Springs
NGET	National Grid Electricity Transmission
NLB	Northern Lighthouse Board
NtM	Notice to Mariners
PAC	Polyanionic cellulose
PLONOR	Pose Little or No Risk to the Environment
PPA	Peterhead Port Authority
PPL	Prysmian Powerlink
PWD	Pressure While Drilling
SSEN Transmission	Scottish and Southern Electricity Networks Transmission
TCI	Tungsten Carbide Insert

1 Introduction

This Method Statement has been prepared to describe the landfall Horizontal Directional Drilling (HDD) operations in Sandford Bay, Scotland, for the Eastern Green Link 2 (EGL2) submarine High Voltage Direct Current (HVDC) link, henceforth the EGL2 Marine Scheme.

EGL2 is a Joint Venture (JV) between National Grid Electricity Transmission (NGET) and Scottish and Southern Electricity Networks (SSEN) Transmission, hereafter referred to collectively as 'the Licensee'. Prysmian Powerlink (PPL) is the appointed Principal Contractor for the EGL2 Marine Scheme.

HDD operations which cross Mean High Water Springs (MHWS) will be performed as per Part 2, Phase 2 of the Marine Directorate Licensing and Operations Team (MD-LOT) Marine Licence MS-00011033. These works are indicatively planned to commence mid Q2 2026.

The document is provided in association with Condition 3.2.6 - Cable Burial Protection Plan (CBPP) of the Marine Licence MS-00011033. Whilst the finalised CBPP will not be submitted until Phase 3 of the works (as per Part 2 of the Marine Licence) this Method Statement will feed into the finalised CBPP and is provided as discussed with MD-LOT in relation to Phase 2 licensable activities.

2 HDD and Installation Operation Sequence

2.1 Overview

The HDD works at Sandford Bay, Scotland will see the installation of two parallel 16 inch (") steel ducts from a defined onshore location (HDD Entry Point) to a nearshore marine location (HDD Exit Point). The HDD ducts (HDD01 and HDD02) shall be installed over a length of up to 1,200m (from the HDD entry Point). As a base case, the installation of HDD01 will be fully completed prior to starting HDD02. However, operational and site constraints might lead to the requirement to commence drilling activities on HDD02 prior to completion of HDD01.

The HDD works also comprises the landfall site preparation, the steel duct welding and installation, as well as the marine assistance for HDD works at both locations. However, this document focuses on the marine works only as per the Marine Licence MS-00011033 i.e., works which take place seaward of MHWS.

The HDD Exit Point will be located in water depth at approximately 12 m Lowest Astronomical Tide (LAT), as a result of the HDD Plan and Profile adjustments following the geophysical and geotechnical investigations completed in 2025.

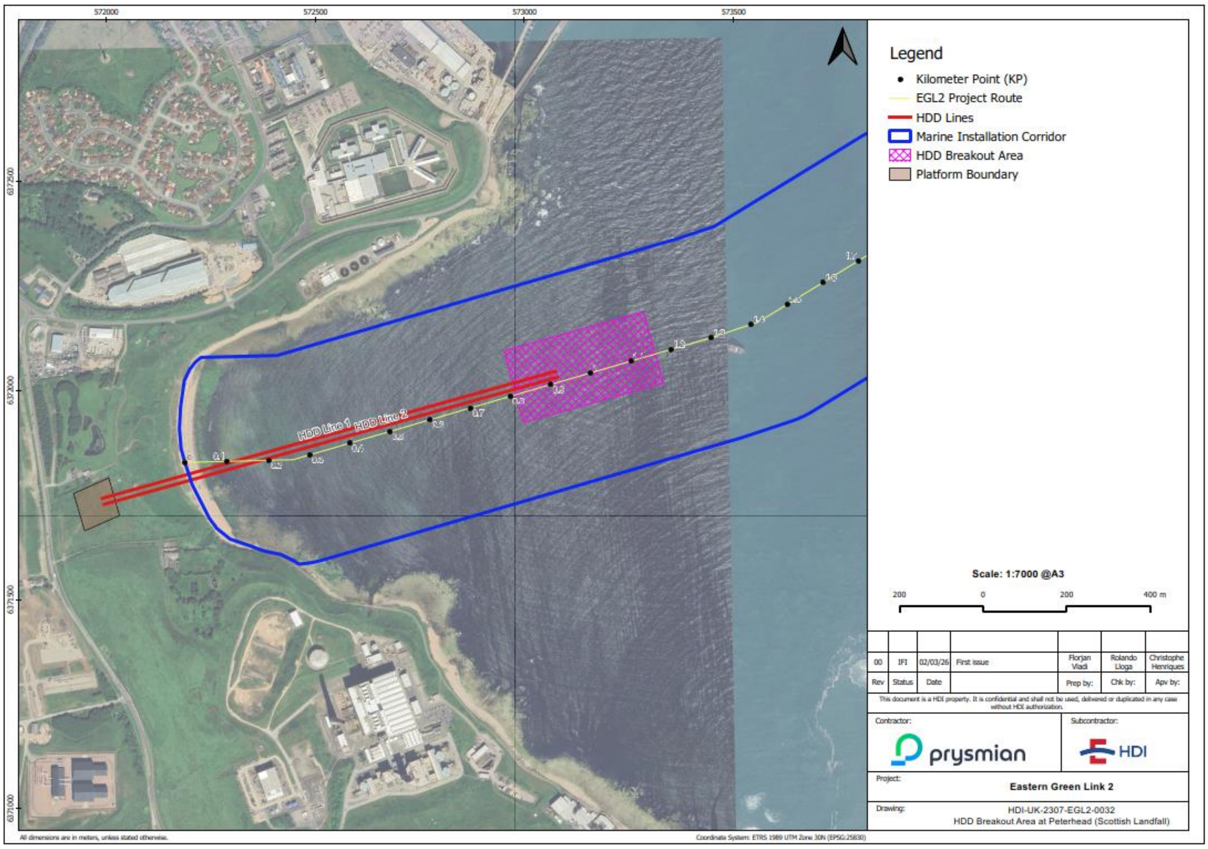

Figure 2-1 HDD Exit Point, Sandford Bay, Scotland

2.2 Duct Installation Sequence

For the installation of the ducts, the following sequence of operations will be followed:

1) Pilot Hole Drilling (from onshore to offshore) using a 12 ¼" or 14 ¾'' drilling assembly (in between those sizes). Pilot hole drilling is to be stopped before punching out from the seabed. The distance for stopping the pilot hole drilling is approximately 170 m before reaching HDD exit point.

   Retrieval/Trip-out of the pilot hole drilling assembly to the HDD entry point (onshore).

   Use of airlift at the extremity of the casing to reduce annular pressure in the HDD borehole and mitigate the drilling fluid losses or eventual frac-outs.

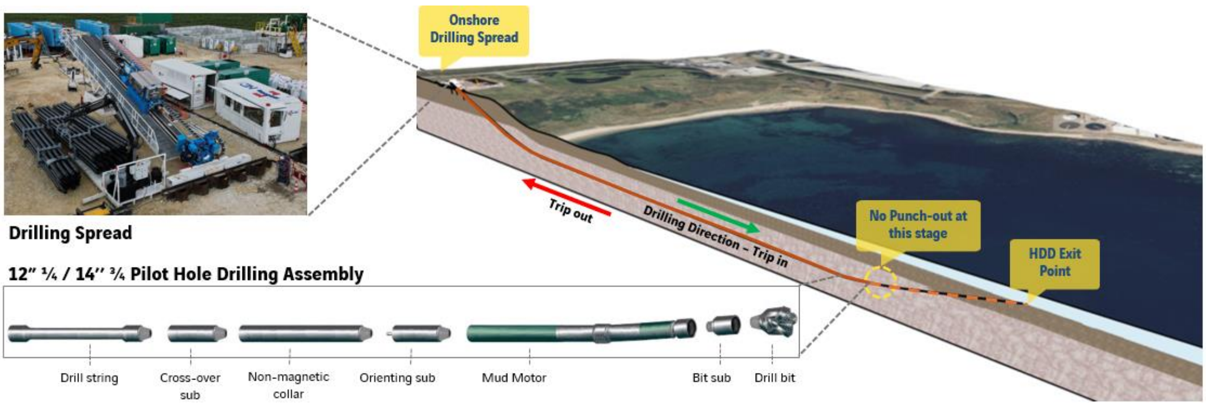

Figure 2-2 Pilot Hole Drilling phase schematic

2) Large Pilot Hole Drilling (from onshore to offshore) using an up to 18'' ¾ drill bit and mud motor. As the initial pilot hole, the large pilot hole is to be stopped before punching out from the seabed as per Figure 2-2.

   Retrieval/Trip-out of the pilot hole drilling assembly to the HDD entry point (onshore).

3) Push Reaming to enlarge the HDD borehole from onshore to offshore to a diameter of 24" using a Tungsten Carbide Insert (TCI) Hole Opener. Reaming will be stopped before punching out and before the end of the stopped Pilot Hole (as per Figure 2-3). This reaming stage is to increase the annular space in the first half of the HDD alignment (including the entry curve); therefore, it's not planned to complete the whole length with it. This reaming pass is a mitigation measure for ground risks in the first section of the HDD alignment. If the expected length cannot be achieved, next planned operations can continue.

   Retrieval/Trip-out of TCI Hole Opener 24" to the HDD entry point (onshore).

   Use of airlift at the extremity of the casing to reduce annular pressure in the HDD borehole and mitigate the drilling fluid losses or eventual frac-outs.

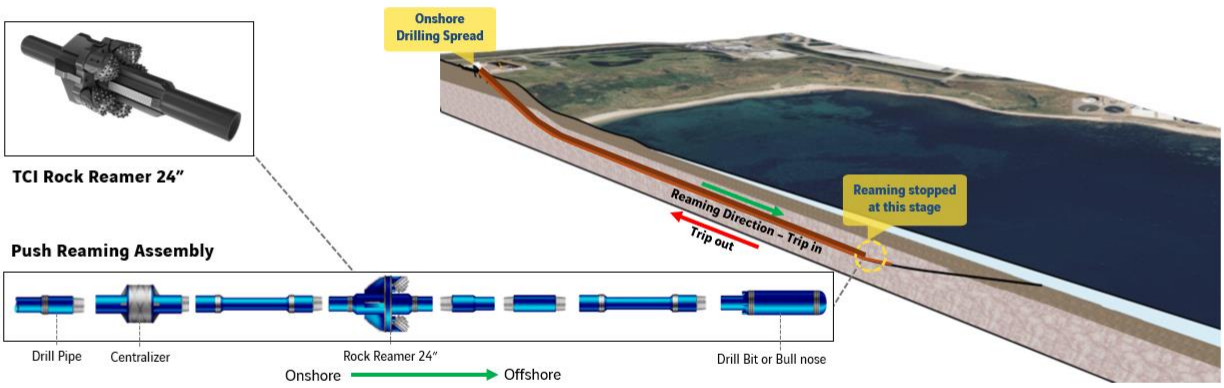

Figure 2-3 Push-Reaming 24" phase schematic

4) Punch out of the 18” ¾ Pilot Hole Drilling Assembly in the pre-excavated area on the seabed. This operation comprises the connection of the drilling assembly (onshore) and then the trip-in (drilling assembly is pushed into the HDD borehole to finally drill the remaining length achieving the final HDD length (approximately 1,200 m)) as per Figure 2-4. Due to the alluvial formations which will potentially be encountered in the final section of the HDD alignment (granitic gravel and marine sediments), a Jetting Assembly might be used. This configuration of pilot hole assembly is adapted to ground formations composed by non-cohesive materials such as sand, that could be present when approaching the exit point.

   Use of an airlift system at the end of the casing to reduce annular pressure within the HDD borehole, thereby minimising drilling fluid losses and preventing potential frac-outs.

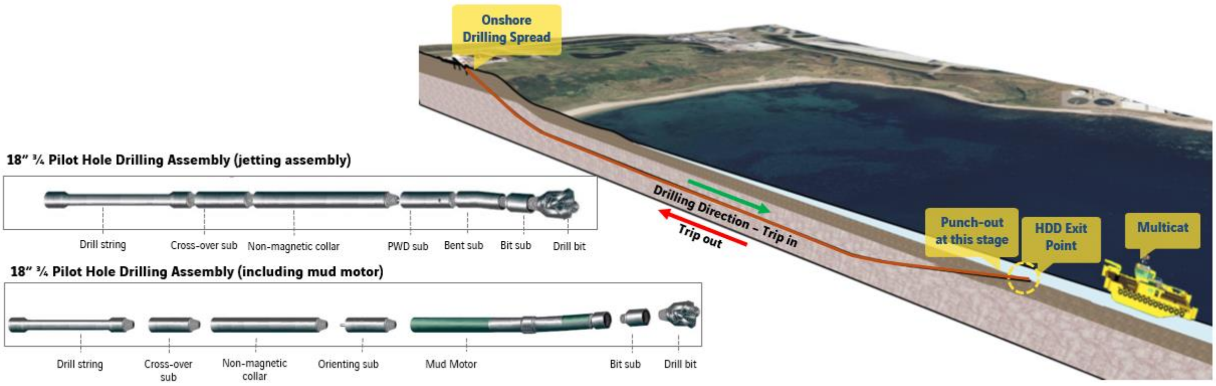

Figure 2-4 Pilot Hole Punch-out phase schematic

   The drilling assembly punches out at the HDD exit point (seabed) in a pre-excavated area (HDD Exit Pit), cleared from boulders, cobbles or any debris which may cause the collapse of the HDD borehole or interfere with the next operations (see Section 3 below).

   Diver survey and verification of Pilot Hole Punch-out location on seabed.

   Retrieval/Trip-out of the drilling assembly to the HDD entry point (onshore).

5) A 16” Calliper Bull Nose (commonly known as “Torpedo”) will be tripped in from onshore to offshore to check the HDD borehole after the punch out and prior to the duct installation (see Figure 2-5). As result of this check, two different operational decision can be made:

   - If the HDD borehole is mostly clear/free of obstructions all along the drilled length:
     - The 16” Torpedo will be connected at the HDD exit point to a winch wire attached to a winch mounted on the multicat deck nearshore.

    - This winch wire will assist the duct installation by keeping tension on the duct string to mitigate the risk of duct buckling or blockage in the HDD hole.
- If the HDD borehole presents obstructions or localised collapses:
    - Re-drill using 18" ¾ Pilot Hole Drilling Assembly to re-open and clean the HDD borehole, especially in the alluvial sections close to the exit.
    - The 16" Torpedo will be tripped in from onshore to offshore.
    - Once this second running of the Torpedo confirms that the HDD borehole is free of obstructions, then it will be connected at the HDD exit point to a winch wire attached to a winch mounted on the multicat deck.

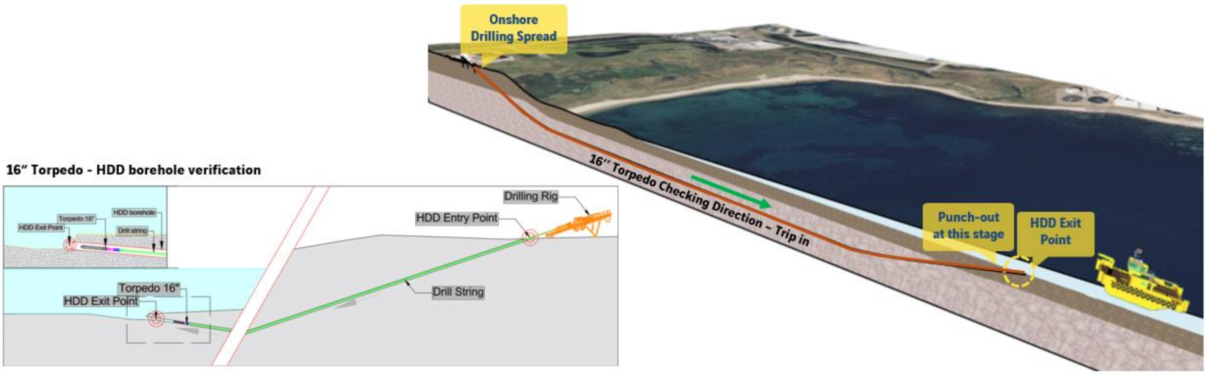

Figure 2-5 16" Torpedo – HDD borehole checking pass schematic

6) Trip-out of the 16" Torpedo to the HDD entry point, bringing the winch wire end to onshore, which is simultaneously spooled out from the multicat vessel's winch. At this point, the winch wire will be passing through the HDD from its exit in the seabed to its entry onshore (see Figure 2-6).
7) The winch wire will be connected to the Pulling Head at the extremity of the first steel duct section to be installed into the HDD hole (pushed). At the other end, the winch wire is held by the winch mounted on the multicat's deck.

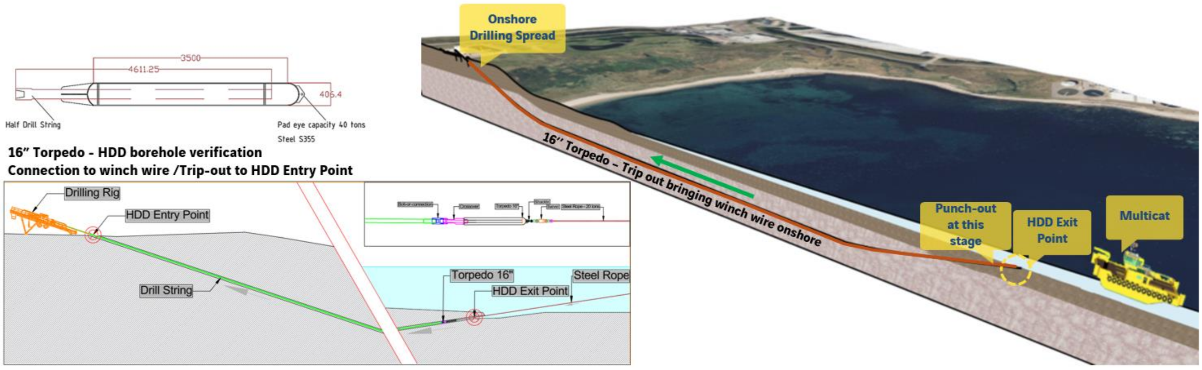

Figure 2-6 Trip-out of 16" Torpedo – Steel rope back to onshore schematic

8) Installation of the ducts, by pushing 12 to 24 m long 16" diameter steel duct sections from the onshore HDD entry point. The sections of steel duct are welded together or threaded, before each section is pushed by the drilling rig into the HDD hole.

   This operation comprises the pushing and clamping of the steel double jointed ducts into the HDD hole using the drilling rig. This operation will be assisted by the winch wire connected to the winch on the multicat's deck to keep tension on the duct string during installation, therefore minimising the risk of duct buckling or blockage (see Figure 2-7).

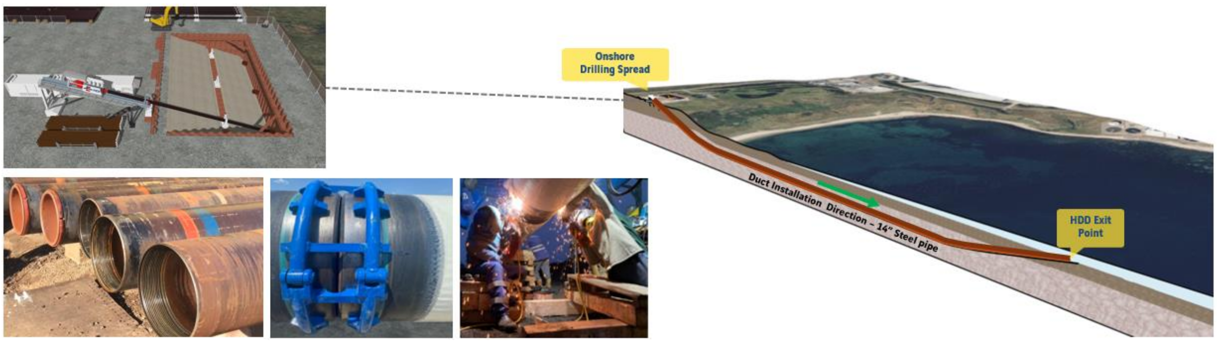

Figure 2-7 Installation of 16" Steel ducts (pushing) schematic

9) Completion of the 16" steel duct installation. At the offshore side, once the extremity of the duct comes out on the seabed, divers will disconnect the winch wire from the end of the steel duct.
10) Cut off the Pulling Head at the end of the steel duct by divers.
11) Installation of a multigrip flange at the end of the steel duct by divers.
12) Installation of messenger line and end flange. A messenger line will be pushed through the duct from onshore to offshore by pumping water down the duct to push the calliper pig to the HDD exit. Recovery of messenger line connected to the

calliper pig (hook) by divers. Connection of the messenger line to the hook on the inner face of the plate (blind end flange) by divers (see Figure 2-8).

13) Closing of the end flange by divers.

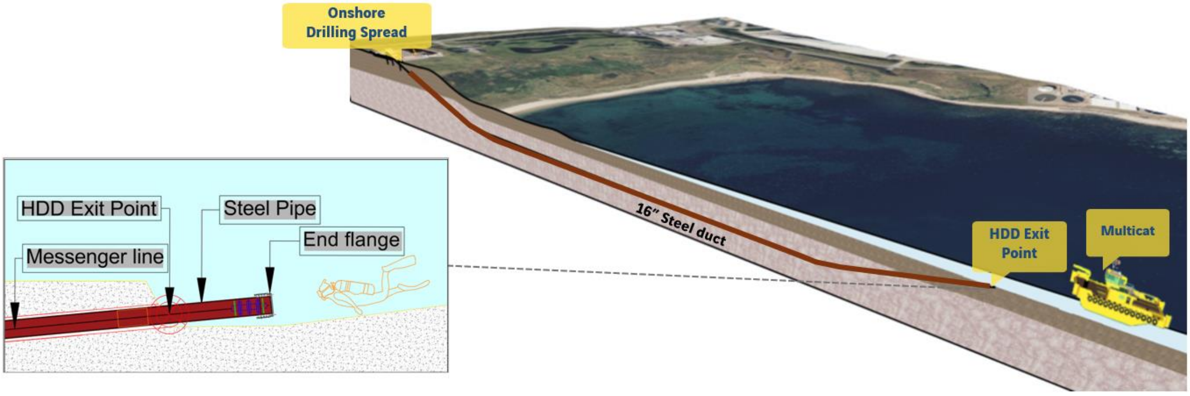

Figure 2-8 Installation of messenger line and end flange schematic

14) The aforementioned sequence is repeated for HDD02.

3 Marine Works

3.1 HDD Exit Point Excavations

The HDD Exit Point excavations will have the following parameters:

- Water depth at exit: approximately 12 m LAT;
- Distance between HDD exit points: 15 m;
- Depth of excavation: up to 4 m;
- Footprint of the excavation: up to 1,500 m^2;
- Volume to be excavated: up to 4,000 m^3;
- Ratio of 1/3 for excavation side slopes, as per diver's safety requirement; and
- The seabed geology varies from silty sand at the upper layer to medium dense silty slightly clayey sand with presence of boulders.

The HDD Exit Point excavations will be performed prior to the punch-out of the pilot hole. As per the inputs described above, the following are planned:

- An exit pit excavation for each exit points (each HDD) will be required (see schematic in Figure 3-3).
- The excavation will be performed using a Mass Flow Excavator (MFE) or Controlled Flow Excavation (CFE) (as shown in Figure 3-1) due to the required excavation depth and nature of the seabed sediments. The excavated material will be spread over the seabed around the exit pit, by the nature of MFE/CFE activities.

- A natural backfilling of the excavation will happen due to known tidal currents in Sandford Bay. A few days after completion of the works a Multibeam Echo Sounder (MBES) survey will be performed to identify the volumes of sediments brought back by the currents into the excavated area. Note that part of excavated area will be occupied by the duct and its temporary protection measures (Section 3.2) which means that volume to be backfilled will be less than the originally excavated.
- A long reach excavator deployed on a flat top spud leg barge may be required as a contingency measure, in the event that the MFE/CFE cannot achieve the required excavation depths due to unfavourable ground conditions (see Figure 3-2).

  Material excavated from the exit pit using the long-reach excavator would be temporarily side-cast on the seabed immediately adjacent to the excavation area. Excavated material from the long-reach excavator would be placed in controlled spoil berms adjacent to each exit pit to allow re-handling and reinstatement following completion of the works.

  The berms would not exceed the permitted 5% reduction in the navigable water depth in the work area (60 cm approx. for 12 m water depth). Therefore, the berms must keep a low profile using the Excavator bucket and the Prolec system on the excavator to confirm height of the berms. According to this constraint and the volume to be excavated the maximum surface of the berms (all combined) will be 5,000m2. Part of the material will unavoidably spread out due to effect of the currents.

  Following completion of installation works, the material would be redistributed to reinstate the seabed profile.

Figure 3-1 Controlled Flow Excavator (CFE)

Figure 3-2 Long reach excavator on a barge

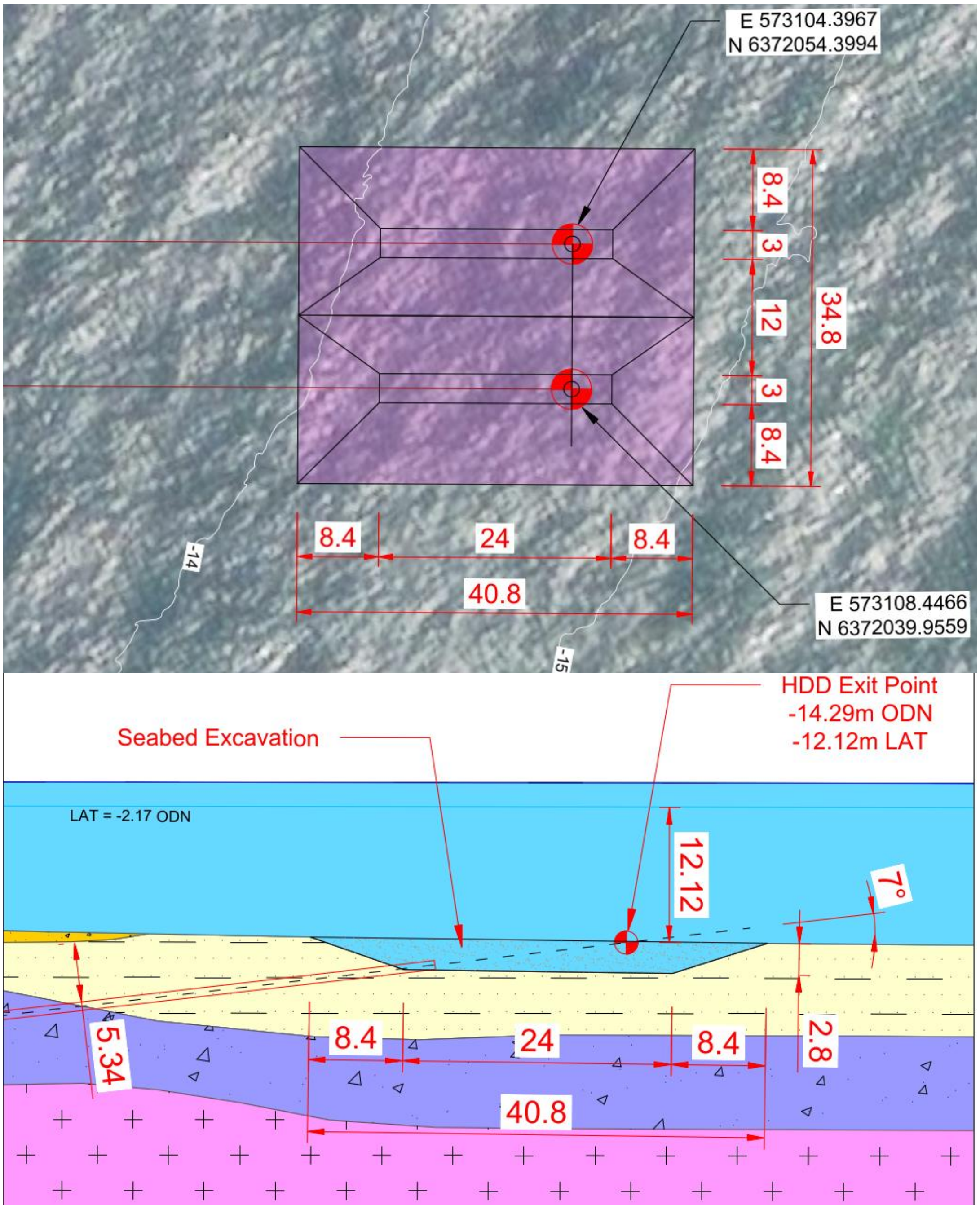

Figure 3-3 Indicative exit excavation layout

3.2 HDD Exit Point Temporary Protection

It is not planned to install temporary protection at the HDD exit points during the HDD works.

Once the steel duct installation is completed for both HDD01 and HDD02 (including messenger line and end flange installation), temporary protection will then be required to secure the ducts in the seabed until the cable pull-in and installation activities commence.

The end of the HDD ducts will be left at the bottom of the HDD exit pit excavation. According to the schedule seabed deposits under Marine License MS-00011033, concrete mattresses are the material to be used to temporarily secure and protect the ducts. If concrete mattresses are used for temporary protection of the HDD ducts, the following details shall apply:

- Up to four mattresses per duct will be required (up to 8 mattresses in total);
- A maximum of 72 tonnes of concrete mattresses will be required;
- Each mattress will have approximate dimensions of 6 m x 3 m x up to 0.3 m, with a weight of 9 tonnes;
- The concrete mattresses will be installed from a multicat vessel (or similar), using an onboard crane, potentially supported by divers;
- No reduction in navigable water depth is anticipated due to the temporary installation of the concrete mattresses, the mattresses will be positioned within the excavated HDD exit pit and will not protrude above original seabed level; and
- The concrete mattresses will be removed entirely upon the commencement of the cable pull-in activities – permanent protection of the HDD exit pit, ducts and cables will be undertaken following cable installation, and subsequent to discharging Phase 3 of the Marine Licence.

However, the marine assistance specialists recommend the use of rock bags to provide temporary protection of the HDD ducts within the exit pit, instead of concrete mattresses. This is because of the potential risk of damage to the HDD ducts due to the likely point loading from concrete mattresses, resulting from their ridged nature. Rock bags are more compliant in nature, and will contour around the HDD ducts, thus removing the risk of point loading damage to the newly installed infrastructure.

Therefore, rock bags will likely be utilised, subject to a variation of the Marine Licence MS-00011033 to include temporary rock bags in the schedule of deposits being approved by MD-LOT. If the use of rock bags is not approved by way of a Marine Licence variation, temporary protection of the HDD ducts within the exit pit will be achieved using concrete mattresses, as detailed above.

A Marine Licence variation request has been submitted to MD-LOT to allow for the use of rock bags to provide temporary protection of the HDD ducts in the exit pit. Should the Marine Licence variation be approved by MD-LOT, and temporary rock bags are included in the schedule of deposits, the following details will apply for the temporary HDD duct protection:

- Up to 10 rock bags per HDD duct (up to 20 bags in total);

- A maximum of 40 tonnes of clean crushed rock material in total (contained within net bags);
- Each rock bag will have a diameter of approximately 1.5-2 m, with a weight of approximately 2 tonnes;
- The rock bags will be installed from a multicat vessel (or similar) using an onboard crane, potentially supported by divers;
- No reduction in navigable water depth is anticipated due to the temporary installation of the rock bags, the rock bags will be positioned within the excavated HDD exit pit and will not protrude above original seabed level; and
- The rock bags will be removed entirely upon the commencement of the cable pull-in activities – permanent protection of the HDD exit pit, ducts and cables will be undertaken following cable installation, and subsequent to discharging Phase 3 of the Marine Licence.

At the completion of the HDD works, coordinates of the HDD Exit Point will be provided to MD-LOT and relevant maritime stakeholders. As there will be nothing protruding above the natural seabed profile, it is not considered necessary to physically mark the location. Nonetheless, the requirement for temporary Aids to Navigation (AtoNs) to mark the HDD exit pit and associated temporary protection measures will be informed through engagement with Peterhead Port Authority (PPA), the Maritime Coastguard Agency (MCA) and the Northern Lighthouse Board (NLB). If a temporary AtoN is required, the type and characteristics will be agreed with the NLB and PPA.

The details of the location and nature of the HDD Exit Pit and associated temporary protection measures shall be promulgated through the issue of a Notice to Mariners (NtM), this will also include details of any temporary AtoNs, if present.

3.3 HDD Marine Assistance Vessels

The vessels listed below are required to perform the marine operations to assist the HDD works:

- **Multicat (self-propelled moored barge):** to assist on HDD exit pit excavation using MFE/CFE, diving support, recovery of tools and equipment from the seabed, duct installation and installation of temporary HDD exit protection (Figure 3-4).
- **Long reach excavator on a flat top spud leg barge:** as a contingency to conduct HDD Exit Point excavations, if MFE/CFE is not successful (Figure 3-2).
- **Crew Transfer Vessel:** to ensure crew rotation/ transfer from Peterhead harbour to the nearshore work location (Figure 3-4).
- **Light Work Boat:** to act as a survey vessel.

The following ancillary equipment will also be required:

- **Four-point Mooring Spread:** To provide multicat vessel station keeping and positioning and create a safe working area. All moorings will be fully within the marine installation corridor, as consented by the Marine Licence (see Figure 2-1), with a combined footprint of up to 32 m^2 at each mooring location.

- **Spudding footprint/placement:** The diameter of the legs is 914mm, area of each spud: 0.66 m² / Number of spuds: 4 / Total footprint: 2.64 m². The barge will be placed next to each HDD exit point allowing a 21m long reach excavator to operate.
- **Dive Chamber and Dive Control Cabin:** mobile unit to support diving operations.
- **Diving Launch and Recovery System (LARS):** Diver LARSs to support diving operations.
- **Survey Equipment:** to perform bathymetric surveys, including MBES operating at >200 kHz.

Figure 3-4 Multicat (left) and Crew Transfer Vessel (right)

3.4 Diver Operations

Divers are planned to perform the following activities:

- Inspection of initial 18'' ¾ Pilot Hole punch-out.
- Inspection of 16'' Torpedo punch-out.
- Connection the winch wire to the 16" Torpedo.
- Disconnection of the winch wire from the duct Pulling Head.
- Removal of the Pulling Head from the end of the steel duct.
- Installation of a multigrip flange at the end of the steel duct.
- Duct pigging and installation of messenger line and end flange.
- Installation of temporary duct protection.

3.5 Marine Works Sequence of Events

1) Mobilisation to Peterhead of multicat, auxiliary vessels, divers and associated equipment.
2) Excavation of the HDD Exit Pit covering both HDD exits will be undertaken using an MFE/CFE, or potentially a barge mounted long reach excavator if soil conditions require.

3) Once the 18 ¾" Pilot Hole Drilling Assembly punches out at the HDD Exit Pit (bottom of the excavation), divers will be sent to inspect the punch out location (Figure 3-5). The Pilot Hole Assembly will be tripped out, back to HDD Entry Point. No tool disconnection and recovery at sea are required at this stage.

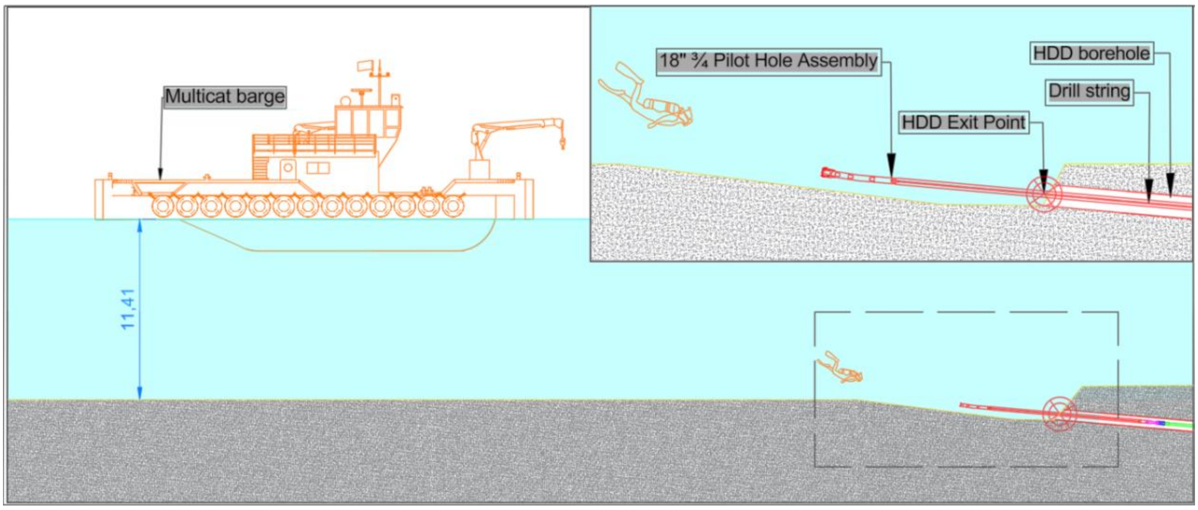

Figure 3-5 Nearshore Assistance – Pilot Hole Punch-Out Inspection.

4) Once the 16" Torpedo (HDD borehole checking tool) pops out at the HDD Exit Point (bottom of the excavation), divers will be sent to inspect the pop out location (Figure 3-6).

5) If 16" "Torpedo" running cannot complete the full length of the HDD, the HDD Borehole will be redrilled using an 18 ¾" Pilot Hole Drilling Assembly and the sequence returns to step 3).

6) The divers will connect the 16" Torpedo to the winch wire attached to winch mounted on the multicat deck. This winch wire will assist the duct installation by keeping tension on the duct string to mitigate the risk of duct buckling or blockage in the HDD borehole (Figure 3-7).

7) Trip-out of the 16" Torpedo to the HDD entry point, bringing the winch wire end to onshore, which is simultaneously spooled out from the vessel's winch (Figure 3-8). At this point, the winch wire will be passing through the HDD from its exit in the seabed to its entry onshore.

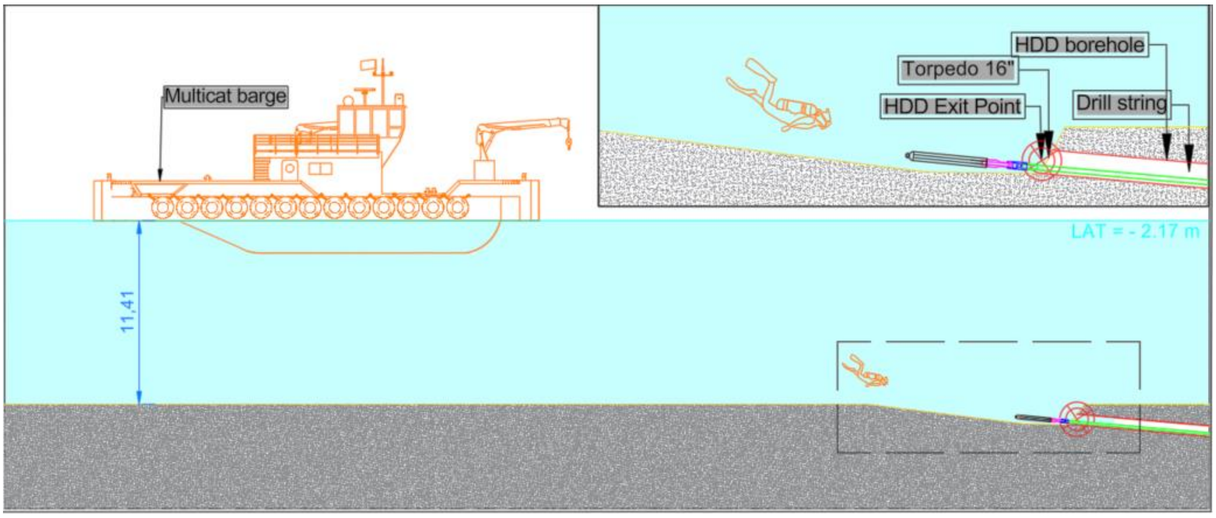

Figure 3-6 Nearshore Assistance – Inspection of 16'' Torpedo pop out.

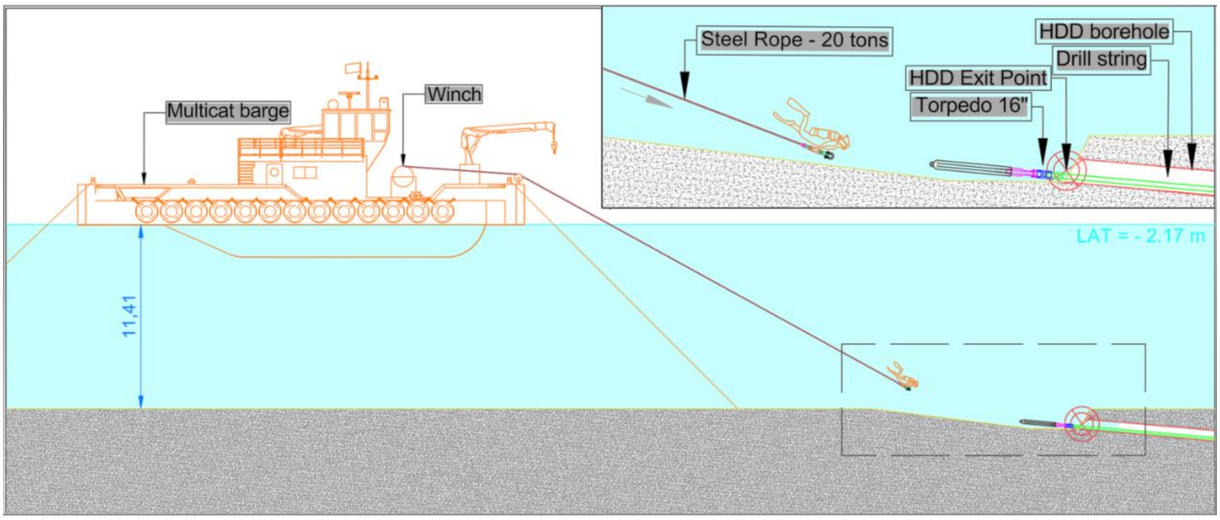

Figure 3-7 Nearshore Assistance – Connection of the winch wire to the 16" Torpedo.

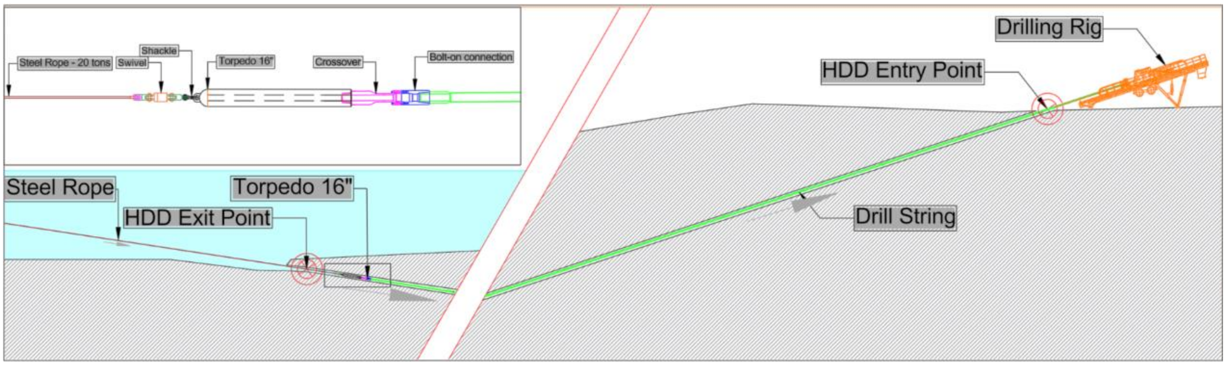

Figure 3-8 Nearshore Assistance – Trip out of 16" Torpedo (with winch wire attached).

8) Assistance during 16” steel duct pushing (from onshore to offshore). This operation will be assisted by a winch wire connected to a winch on the multicat’s deck to keep tension on the duct string during installation for minimising the duct buckling or blockage (Figure 3-9).

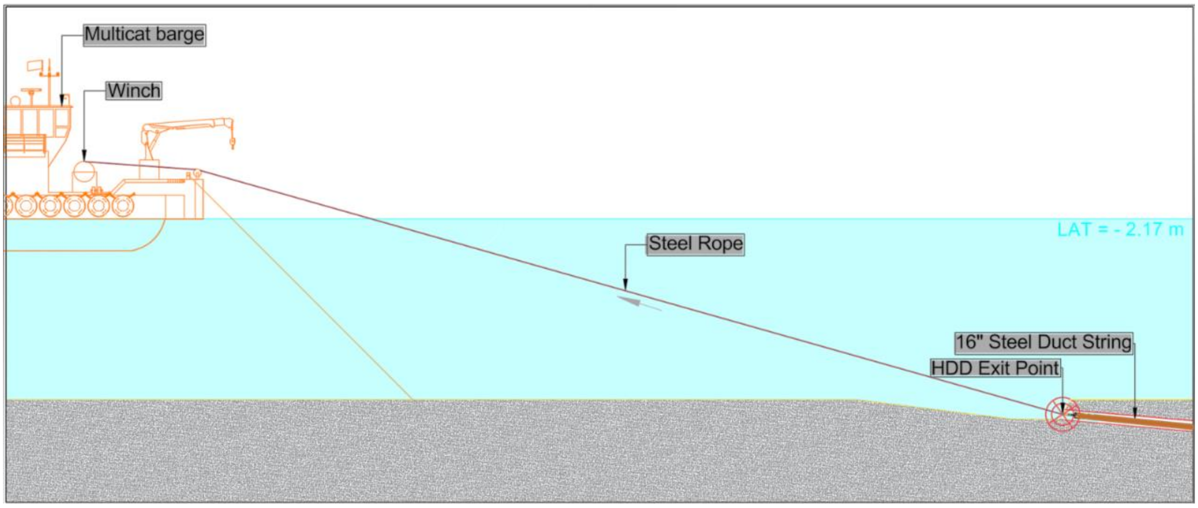

Figure 3-9 Nearshore Assistance – Assistance during 16” steel duct installation.

9) Once the full length of the duct is installed (up to 1,200 m), the pulling head at the end of the 16” steel duct string shall emerge at the HDD exit point, pushed by the onshore drilling rig and simultaneously assisted by the winch wire to keep the tension.

10) The winch wire will be disconnected from the Pulling Head by divers. The winch wire will then be recovered back to the multicat (Figure 3-10).

11) The Pulling Head and end of the steel duct will then be cut off the duct and recovered by divers.

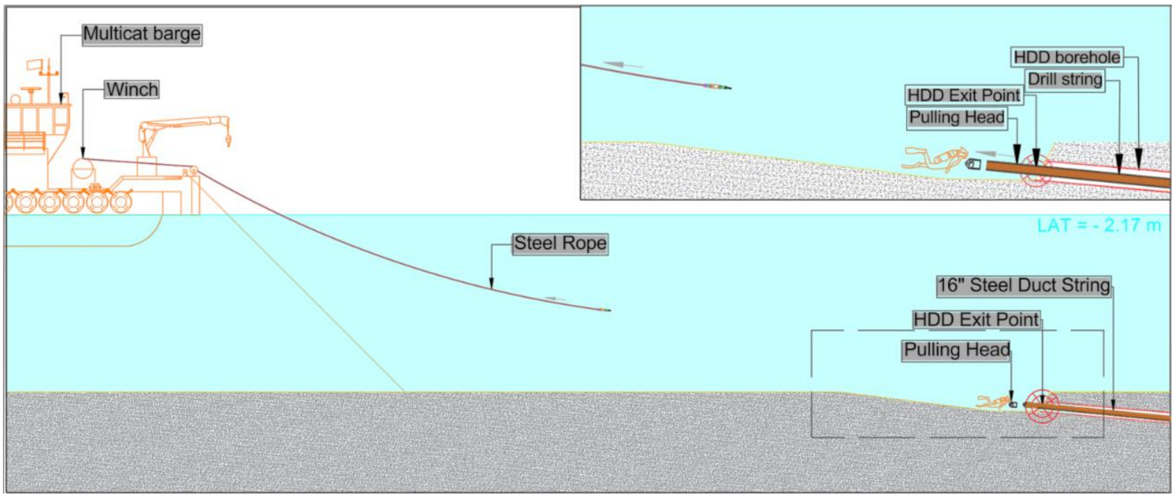

Figure 3-10 Nearshore Assistance – Disconnection of the winch wire and removal of the pulling head.

12) Installation of a Multigrip coupling (mechanical joint) by divers at the end of the steel duct at the HDD exit point.

13) Recovery of the messenger line attached to the calliper pig (hook), which is pushed through the duct from the HDD entry point to the HDD Exit Point using water (hydraulic pushing) (Figure 3-11).

14) Connection of the messenger line to the hook on the inner face of the plate (blind end flange). The messenger line is to be used later in the cable pull-in phase – to be attached to the cable in order to pull it landwards through the completed HDD duct. Closing of end flange by divers (Figure 3-11).

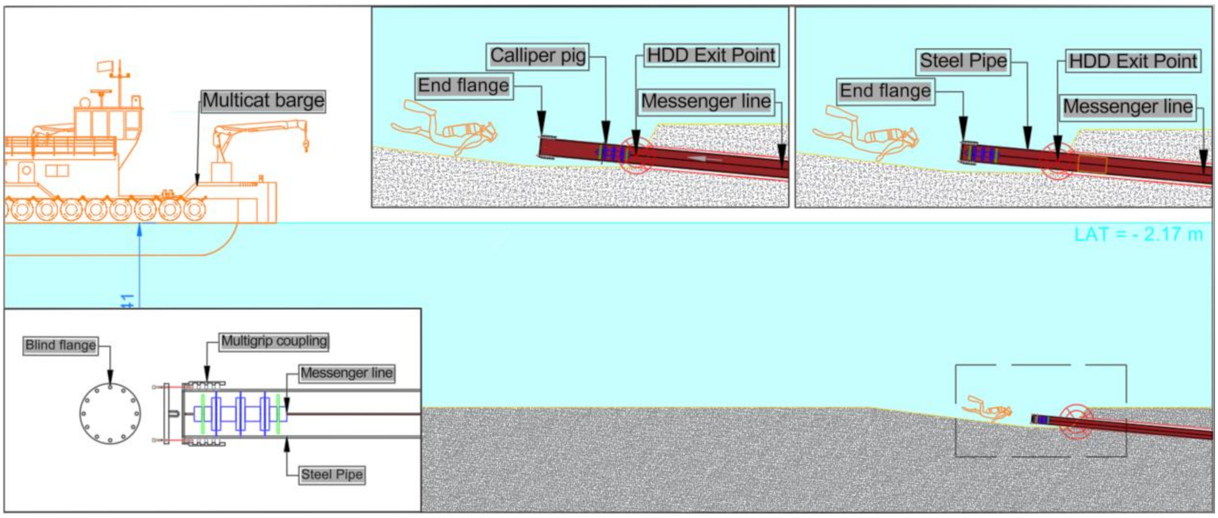

Figure 3-11 Nearshore Assistance – Duct Pigging, Messenger Line and End Cap installation

15) Repeat steps 3-14 for the second HDD duct installation (HDD02).

16) Temporary protection of the ducts, once HDD works are complete for HDD01 and HDD02 as detailed in section 3.2 (Figure 3-12).

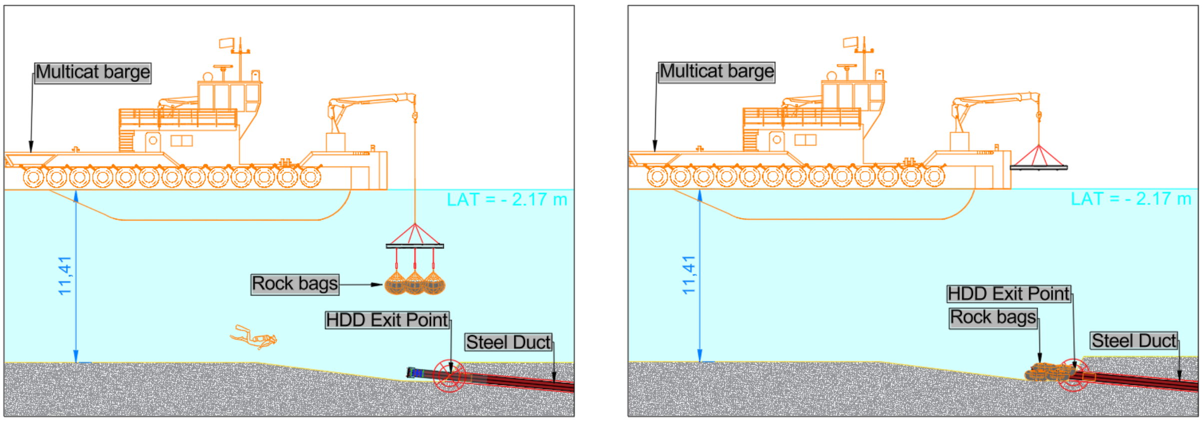

Figure 3-12 Nearshore Assistance – Duct Temporary Protection

4 Drilling Fluid Management

The drilling fluid management process (described in detail below) is aligned with the approved EGL2 Marine Scheme Construction Environmental Management Plan (CEMP) (Document ID PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0001).

4.1 Drilling Fluid

The drilling fluid primarily consists of 4% bentonite (montmorillonite clay), 1% additives (see Section 4.3), and 95% fresh water. Montmorillonite clay is a naturally occurring mineral with swelling properties that enable the formation of a slurry-like fluid with minimal solid content when mixed with water. Bentonite is listed on the OSPAR List of substances used and discharged offshore which are considered to Pose Little or NO Risk (PLONOR) to the environment.

4.2 Drilling Fluid System Process

During drilling operations, drilling mud will be continuously pumped through the drill pipes and downhole tools, then returned to the surface for recycling and reuse. The primary functions of the drilling mud—such as borehole cleaning, stabilisation, and partial lubrication—are governed by a standard 'recipe', which will be validated and adjusted based on conditions observed on the drilling hole. Drilling fluids will be recycled, treated, and reused as far as possible, and any waste drilling muds will be transported offsite for treatment and disposal at a licenced facility. The drilling fluid process is shown below in Figure 4-1.

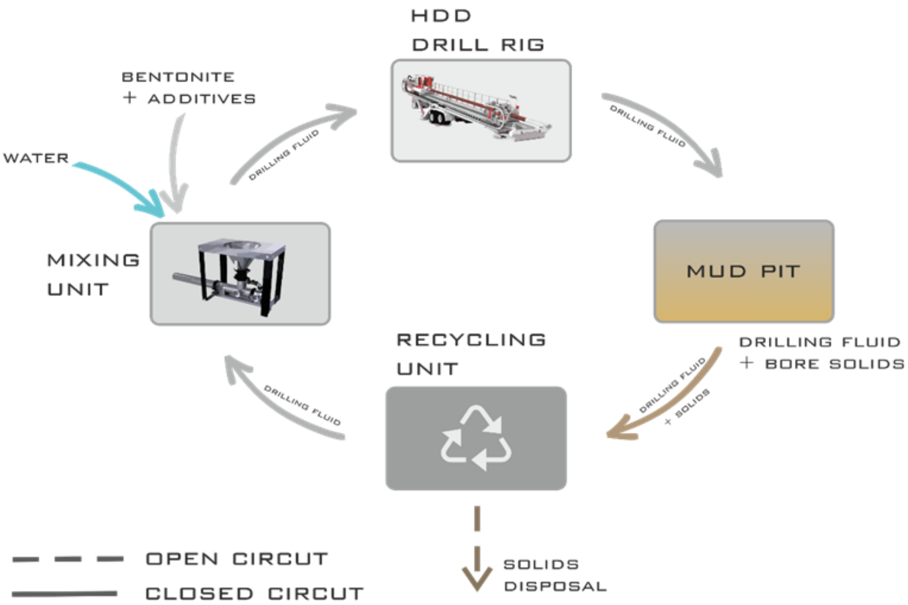

Figure 4-1 - Drilling Fluid Flow Diagram

4.3 Modifications

Initially, typical additives used to adjust drilling fluid properties and control fluid loss—such as soda ash, xanthan gum, lubricants, polyacrylamides, anionic thinners, cellulose, starch, or other substances approved under the OSPAR PLONOR list—will be used. The Drilling Fluid Engineer will be responsible for selecting appropriate proportions and compositions of these components on an ongoing basis, in line with the progress of the works and the specific geological conditions encountered. The indicative drilling fluid products list is provided below in Table 4-1.

Table 4-1 Indicative Drilling Fluids Product List

Product	Application	Classification	Registration Code	CAS Number*
Bentonite	Viscosifier	Cefas	29757	1302-78-9
Soda Ash	Increase pH/Reduce hardness	Cefas	29813	497-19-8
PAC H	Filtration control	Cefas	29758	9004-32-4
Xanthan Gum	Gel strengthener	Cefas	29756	11138-66-2
Lost Circulation Material (LCM)	Prevent fluid losses into the ground	Cefas	30743[1]	12001-26-2 *(mica group of minerals)*

**Cefas (2025) OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (PLONOR)*

[1] Registration Code may vary according to the supplier. In any case, an LCM product based on Mica or similar will be used.

4.4 Reducing Drilling Fluid Loss to the Marine Environment

The pilot drill bits will punch-out at the seabed. Drilling fluids will be released to the marine environment during this process, as the punch-out locations are subtidal (see Table 4-2 for estimated drilling fluid losses). Losses of drilling fluids are unavoidable during punch out; however, losses will be minimised insofar as practicable in line with the EGL2 Marine CEMP.

Around 170 m before punch-out is achieved, a Torpedo run of the bore will be conducted to check the state of the HDD Borehole. This checking run continues until punch-out onto the seabed. Whilst some drilling fluid contained in the HDD borehole will inevitably be lost to the water column, the volume of drilling fluids in the bore will be reduced as far as is practicable prior to breakout occurring and will consist of a non-toxic bentonite slurry.

A mitigation measure to reduce the volume of drilling mud released in the sea is to use an airlift placed onshore that will inject air into the entry casing, close to the bottom end of the casing. This will bring most of the drilling mud back to the HDD entry point, depending on the drilling phase and position of the drilling tool.

4.4.1 Inadvertent Fluid Loss

HDD drilling operations have a potential to release drilling fluids through frac-outs, however, this is considered unlikely, and controls will be in place in order to prevent this from occurring. A frac-out is the condition where drilling fluid is released through a fractured rock formation into the surrounding formation, and travels toward the surface through large, interconnected fissures, cracks or openings in the ground. Frac-outs can also occur where man-made elements are present (e.g., non-sealed ground investigation boreholes), to mitigate this, all the geotechnical boreholes installed during the EGL2 pre-installation surveys were backfilled with a cement-bentonite grout.

Drilling fluid frac-out is most likely to occur close to the HDD Exit Point where the drilling is shallow, nonetheless the potential exists for frac-outs to occur in any location along an HDD bore. During any HDD, the risk of drilling fluid frac-out is higher during the drilling of the pilot hole. During subsequent reaming operations, the risk is reduced as the hole has a bigger annular space which reduces downhole pressure / drilling fluid pressures.

Prior to the start of drilling, the following actions will be undertaken:

- The field crew will be briefed and made aware of the importance of timely detection and response to any frac-out;
- Any third party's crew providing assistance during the drilling works will be briefed and made aware of the importance of timely response to any frac-out;
- Communication systems (mobile phone / radio) will be made available to allow the person checking the HDD alignment to liaise with the drilling superintendent and / or the driller; and
- Monitoring will be conducted in a zone around the drilling site, which will cover the full area behind the drilling assembly and 50 m ahead, as well approx. 20 m on both sides of the midline of the drilling route. It will be checked regularly during low tide in accordance with HSE requirements. Records shall be kept of inspections.

Best efforts will be employed to reduce residual risks and to maintain full annular circulation of drilling fluids.

The control of the properties of the drilling fluids and monitoring of drilling fluid returns at the entry point will be undertaken by a Drilling Fluid Technician, with additional support from a qualified Drilling Fluid Engineer as necessary.

The steering tool used for pilot drilling will be equipped with an annular pressure sensor. The pressure can be viewed in real time and data is stored for the purpose of later analysis / records. The data will be used to interpret the annular condition (loss zones, cuttings build up, etc.,), downhole tooling performance and surface equipment performance. A model of anticipated annular pressures vs. measured depth (based on borehole geometry, rheology and circulation pump rate pressure drops) will be held on site by the steerer, against which comparisons can be made.

Both the data and its interpretation will be recorded in both the drillers log and steering sheets and will be available for inspection. Alarms will be established within the software which will sound if pressure limits are exceeded during drilling. In the event of a lost circulation occurrence, the Pressure While Drilling (PWD) observations will be used to determine exact depth of the loss zone.

The following protocol will be followed in the event that a frac-out is identified:

- Stop drilling immediately;
- Check drilling area for a frac-out;
- If there is a high tide and frac-out cannot be located, stop drilling until low tide allows to check potential frac-out area;
- Trip out drill string to a position where full drilling fluid returns were last observed during drilling;
- To reduce downhole annular pressure, swab drill string but only at distance where full returns are noticeable to the rig side;
- Potentially, if deemed beneficial, change drilling fluid properties to swell in the fracture;
- Continue pumping drilling fluid after waiting for the manufacturer's prescribed period for the remedial drilling fluid to swell – with an aim to close the pathways to the surface (as relevant); and
- Monitor the area to verify if the frac-out channel seals during pumping. The frac-out area shall be monitored at least once per hour to ensure there is no additional spillage outside the affected area.

Fast reporting is an essential component of the control strategy for a frac-out. Emergency telephone numbers are detailed within the EGL2 Marine Scheme Emergency Response Plan (ERP) (PHWH-EGL2-PRYSM-XX-XX-PLN-OS-0001) and are to be available for all the appropriate parties. The Project Manager or Site Superintendent will complete the frac-out report as soon as practicable after the completion of the clean-up (if clean-up is practicable – i.e., if the frac-out occurs on land) and send it to Principal Contractor. If the frac-out occurs within the sea, the frac-out report will also be completed and communicated as soon as possible. However, while clean-up would not be feasible, the drilling fluids used are inert, and, together with the mitigation measures outlined above, any resulting effects would be minor. These effects are also consistent with the assessment of subtidal frac-out presented in the EGL2 Marine Scheme Environmental Appraisal Report[1] (EAR),which concluded that no significant effects would occur.

The following equipment and materials will be available on site (within the onshore HDD works area) should a frac-out occur onshore and the intertidal zone:

- Sandbags;
- Pumps;
- Lay flat hoses and connections;
- Jet washer;

[1] AECOM, 2022. Eastern Green Link 2 - Marine Scheme. Environmental Appraisal Report.

- Brooms;
- Excavator; and
- Barriers or safety cones.

Sandbags will be positioned in the onshore works compound so that they can be deployed quickly to the frac-out area, where that area is on land. A sandbag bund may be constructed around the frac-out area and drilling fluid recovered from the bund using a positive displacement pump to pump from the bund directly back to the drilling fluids tank or by manually sweeping the fluid into a receptor for disposal.

4.5 Remedial Measures and LCM

LCM will be held onsite and mixed with the drilling fluid as a pill to seal loss zones. The loss zone will be accurately positioned using PWD tool and/or identification of vuggy cavernous zones indicated by the driller's observations (bit drop and/or loss in differential pressure). The selected product by the Drilling Fluid Engineer will be defined and used, with a range of grading and type based on the known geological information. Depending on the product type and particulate size, the Downhole Tool (DHT) may need to be tripped out of the hole and removed to enable the spotting of the pill using open-ended drill pipe.

4.6 Drilling Fluid Losses Estimation

Nearshore currents are expected to disperse any discharged bentonite, so effects will be localised and temporary. Nevertheless, mitigation techniques such as deferred punch-out and forward reaming are planned to reduce fluid losses by pausing pilot hole and reaming operations before the final punch-out, minimising the time the hole remains open. Drilling fluid losses may occur during pilot drilling, push reaming, and duct installation, with all losses limited to 12,000 m^3 of fluid and 480 m^3 of solids, in line with the Marine Licence (MS-00011033).

Table 4-2 Estimated Drilling Fluid Losses per HDD

Activity	Estimated Drilling Fluid Losses
12" ¼/14" ¾ Pilot hole drilling (no punch out)	-
Push reaming 24" (no punch out)	-
18" ¾ Pilot hole drilling (punch out)	770 m^3
16" Torpedo – Checking pass (punch out)	880 m^3
16" Steel duct installation	310 m^3
Total	**1,960 m^3**

5 Other Environmental Mitigations

All other environmental mitigations will be adhered to in line with the following approved EGL2 Marine Scheme Consent Plans and documents under the Marine Licence (MS-00011033), as per Table 5-1.

Table 5-1 Approved EGL2 Marine Scheme Consent Plans and Documents

Document	Document Reference
EGL2 Marine Scheme Environmental Appraisal Report	AECOM, 2022
EGL2 Marine Scheme CEMP, including Appendices:	PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0001
• EGL2 Marine Scheme Marine Pollution Contingency Plan	PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0003
• EGL2 Marine Scheme Waste Management Plan	PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0004
• EGL2 Marine Scheme Marine Megafauna Mitigation Plan	PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0005
• EGL2 Marine Scheme Marine Non-Native Species Plan	PHWH-EGL2-PRYSM-MCM-SM-PLN-Z-0006
EGL2 Marine Scheme Communications Strategy - Scotland	EGL2-JV-EM-XX-PL-MC-115
EGL2 Marine Scheme Written Scheme of Investigation	EGL2-JV-EM-XX-PL-MC-128
EGL2 Marine Scheme Fisheries Liaison Co-Existence Plan	EGL2-JV-EM-XX-PL-MC-129