Triton Knoll Offshore Wind Farm Project

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Horizontal Directional Drilling Environmental Information Report

Document in reference to the Triton Knoll Electrical System Order (2016)

Date: October 2018

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1   INTRODUCTION

1.1   Purpose of the Report

This document relates to the consented Triton Knoll Offshore Wind Farm (TKOWF; the Project), which is located off the east coast of England approximately 32km from the Lincolnshire coast and 50km from the coast of North Norfolk (Figure 1-1). The Project has progressed through two separate consent applications, Triton Knoll Offshore Wind Farm Array (TK Array), which was granted development consent on 11 July 2013 and Triton Knoll Electrical System (TK Electrical System), which was granted development consent on 6 September 2016. Following consent awards for the TK Array and Electrical System, the Project is being taken forward as a single development by Triton Knoll Offshore Wind Farm Ltd (TKOWFL). The Project is owned by majority shareholder innogy (59%), along with partners J-Power (25%) and Kansai Electric Power (16%); innogy will manage the construction, operation and maintenance works on behalf of the project partners.

This Environmental Information Report presents the information relevant to the revised methodology proposed by TKOWFL for Horizontal Directional Drilling (HDD) for the two export cables making landfall at Anderby. The use of HDD was assessed within the TK Electrical System Environmental Statement (ES) and is referenced as Condition 9 of the TK Electrical System deemed Marine Licence (dML). The TK Electrical System ES assumed the exit points on the beach for HDDs being within the 'Below Mean High Water Beach Works Area', the 'Above Mean High Water Beach Works Area' or straddling both (Figure 2-1). The TK Electrical System ES also assessed the excavation and re-excavation of six HDD exit points for the relevant receptors.

A revised methodology has been proposed in order to minimise interaction with intertidal receptors such as recreational users and designated bathing waters and this refinement of methodology is the purpose of this report. The revised methodology will reduce the risk of disruption to the public compared to the original methodology which included the excavation pits located on the beach. It is proposed that the exit points of the now two HDDs, and therefore the associated release of drilling mud (Bentonite) is moved offshore below Mean High Water Springs (MHWS) (Figure 2-2). Designated bathing waters were a key consideration during the TK Electrical System application process, which is reflected in the requirement to undertake an assessment of potential effects on bathing water quality as required under Condition 14 of the dML. Full consideration of Condition 14 is presented in Section 3.4.1.

This Environmental Information Report is intended to provide the regulatory authorities (and their statutory advisers, where relevant) with the necessary supporting information to justify that an additional Marine Licence or variation to the existing deemed Marine Licence is not required.

1.2   Background to the Project

TKOWF is located off the east coast of England (Figure 1-1), with the export cable landfalls located at Anderby Creek on the Lincolnshire coast. The footprint of the consented development area is approximately 145km^2.

The Development Consent Order (DCO) for TK Array allows for installed capacity up to 1,200MW. In February 2018, TKOWFL submitted a non-material change application to the Department of Business, Energy and Industrial Strategy (DBEIS) to reduce capacity to 900 MW and up to 90 turbines

and two OSPs. The non-material change was granted by DBEIS on the 3rd August 2018[1]. The DCO for the TK Electrical System allows for up to six seabed export cables to transfer electricity to shore, together with infrastructure to connect the offshore and onshore cables and the associated onshore infrastructure required to transport the power for connection to the National Grid. Based on the reduced capacity only two seabed export cables will be installed to transfer the electricity to the landfall.

The information presented within this report relates solely to works in relation to the TK Electrical System, namely the use of HDD, and the associated release of drilling mud (Bentonite) for the installation of the two export cables. This Environmental Information Report focuses on the offshore, i.e. below MHWS, elements of the export cable and HDD only.

The final design, Construction Method Statement and programme, as required under Conditions (9) and (7) of the TK Electrical System dML will be supplied to the MMO for approval within the required timeframes prior to the commencement of construction. Therefore, all design information presented in this report should be considered preliminary.

1.3   Structure

This Environmental Information Report is structured as follows:

- **Section 1: Introduction** – provides an overview of the purpose of this report, the background of the Project and a summary of the works;
- **Section 2: Description of Works** – details the nature of the works proposed including a method statement and programme;
- **Section 3: Legislation** – details the relevant legislation considered;
- **Section 4: Environmental Assessment** – describes the screening process of the potential environmental effects arising from the intertidal HDD works. Those effects screened-in are then considered in an environmental assessment;
- **Section 5: Characterisation of Cumulative Effects** – considers the potential cumulative effects from the proposed works; and
- **Section 6: Conclusion** – provides the conclusions of the environmental assessment of the proposed works.

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[1]https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010005/EN010005-000904-DECISION%20LETTER%20TRITON%20KNOLL%20OFFSHORE%20WIND%20FARM%20–%20NON%20MATERIAL%20CHANGE.pdf
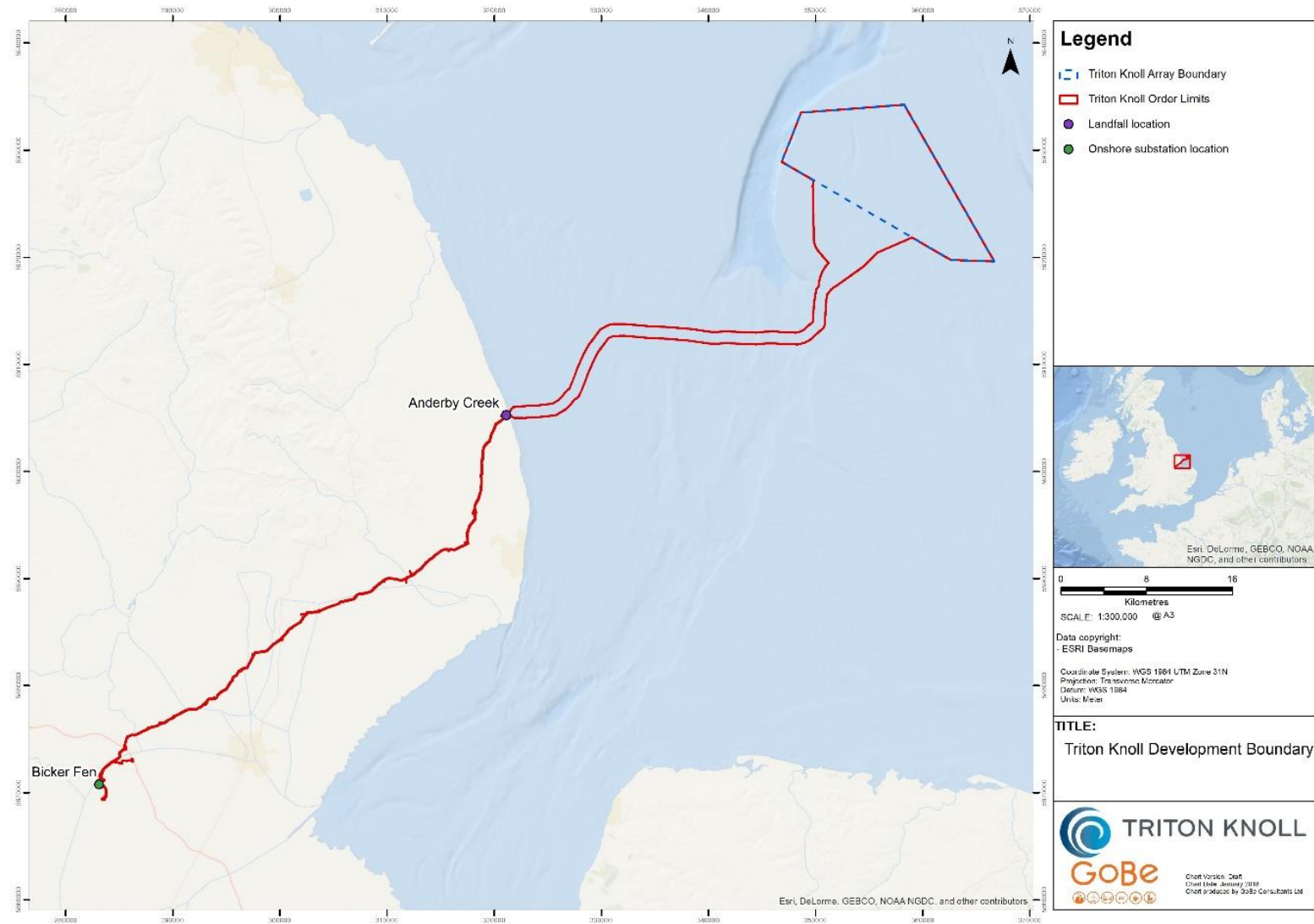
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Figure 1-1: Location of the TKOWF Order Limits

2   DESCRIPTION OF WORKS

The TK Electrical System ES considered three landfall options to connect the offshore export cables with the onshore Transition Joint Bay, landward of the dune system and avoiding interaction with the sand dunes: HDD; microbore; and pipe jacking (a technique which may also be known as horizontal auger boring) (Volume 2, Chapter 1: Offshore Project Description, Document Reference 6.2.2.1). The Project has since confirmed that HDD is the preferred methodology. The use of HDD was assessed within the TK Electrical System ES on the basis of the exit points being in the 'Below Mean High Water Beach Works Area', the 'Above Mean High Water Beach Works Area' (as indicated on Figure 2-1) or straddling both. The TK Electrical System ES considered the installation of six export cables whereas this environmental assessment considers the installation of two, following Project design refinement.

The new proposal for the HDD works, for the installation of the two export cables, will exit within the subtidal zone rather than the intertidal zone (Figure 2-2). Adopting this approach reduces the risk of disruption to the public compared to the original methodology which included the excavation pits located on the beach. The TK Electrical System ES assessed the HDD exit points above MHWS (see Figure 2-1) and that the drilling mud (Bentonite) will be controlled in an excavation pit during exit and either removed or buried following the installation of the cable ducts. The revised methodology presented in this report details excavation pits in the subtidal zone which will result in drilling mud (Bentonite) being discharged into the water column during the initial punch out (see Figure 2-2 and Section 2).

A revised methodology has been proposed by TKOWFL in order to minimise interaction with, and reduce the magnitude of effects in, the intertidal zone identified in the TK Electrical System ES. The intertidal receptors, such as recreational users and designated bathing waters were a key consideration during the TK Electrical System application process, which is reflected in the requirement to undertake an assessment of potential effects on Water Bodies (Condition 14 of the TK Electrical System dML).

The revised methodology is to extend the HDD length to an exit point approximately 650-1250m from the shore, below MHWS (see Figure 2-1). The drill length is anticipated to be approximately 1km, however detailed engineering will confirm exact distances following refraction survey results.

Legend

- Transition Joint Bay Search Area
- Extent of MHWS and MLWS
- Below MHWS Beach Works Area
- Above MHWS Beach Works Area
- Permanent Access Track
- Temporary Construction Compound
- Triton Knoll Order Limits

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

SCALE: 1:5,606.78 @ A3

Data copyright:
- ESRI Basemaps

Coordinate System: WGS 1984 UTM Zone 31N
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

TITLE:
Geographical overview of
TKES ES Landfall

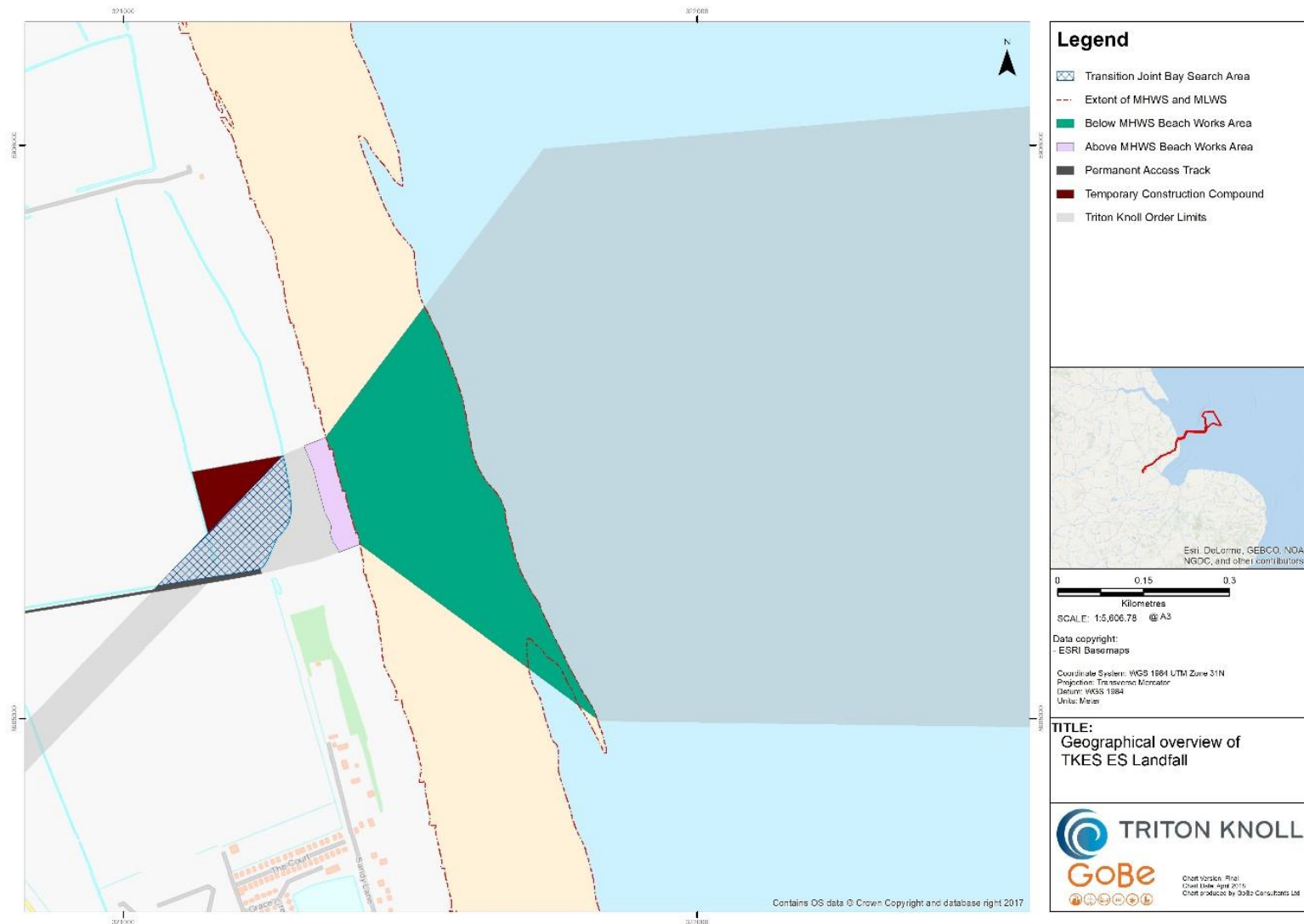Contains OS data © Crown Copyright and database right 2017

Figure 2-1: Geographical Overview of TK Electrical System ES landfall (HDD entry point in the pink shaded box and original exit point in the green shaded box)
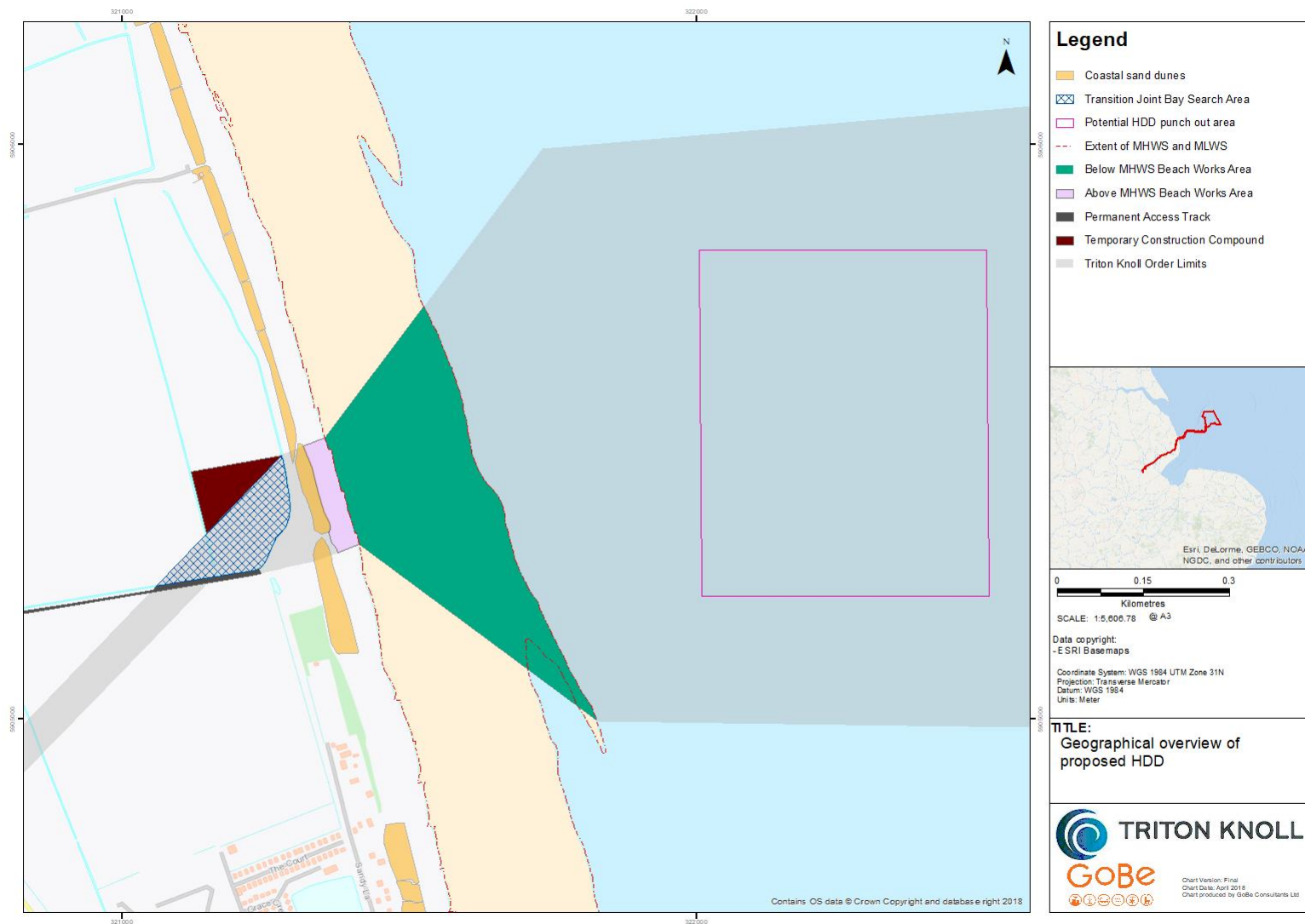
Figure 2-2: Geographical overview of proposed potential area of HDD exit point (within the pink outlined box below MLWS)

2.1 Method Statement

The following method statement is provided to give the regulatory authorities confirmation that the effects associated with the revised methodology remain within the assessment presented in the TK Electrical System ES. It should be noted that a full Construction Method Statement for the HDD works (as required under the dML) will also be provided in Q4 2018, to which it is proposed this document will form an appendix.

2.1.1 Mobilisation and Rig-up

The HDD drill rig (hereafter referred to as the rig) will be surface mounted and used to drive a steerable head which can be monitored very accurately for position throughout the process. The rig will be aligned at the drilling location along the centre line of the cable drilling route and elevated to the requisite entry angle. A mud tank and pumps will be connected to the drilling rig and the drilling bottom hole assembly will be made up.

The base of the excavated HDD entry point on the landward side of the dunes is proposed to be below MHWS and as such there is potential for the pit to be flooded during high water (after punch out – see Section 2.1.2.4). Therefore, it is proposed that an entry basin will be installed with clay dykes high enough to contain the rise of fluids (drilling mud (Bentonite) – see Section 2.3) during high water. The final engineering design of the clay dyke, will be finalised prior to installation and will be presented in the discharge of the relevant Conditions, inclusive of the Construction Method Statement as required under Condition 7(c) of the TK Electrical System dML. Figure 2-3 presents a schematic with associated dimensions of an indicative set-up for illustrative purposes.

The HDD profiles will be determined prior to drilling based on the interpretation and analysis of the refraction survey data (undertaken in Q2 / Q3 2018). Mud pressure and pulling force calculations will also be finalised prior to drilling.

The maximum depth along the route will be determined during the detailed design, following analysis of geophysical data, and will be agreed in consultation with the Environment Agency and the MMO.
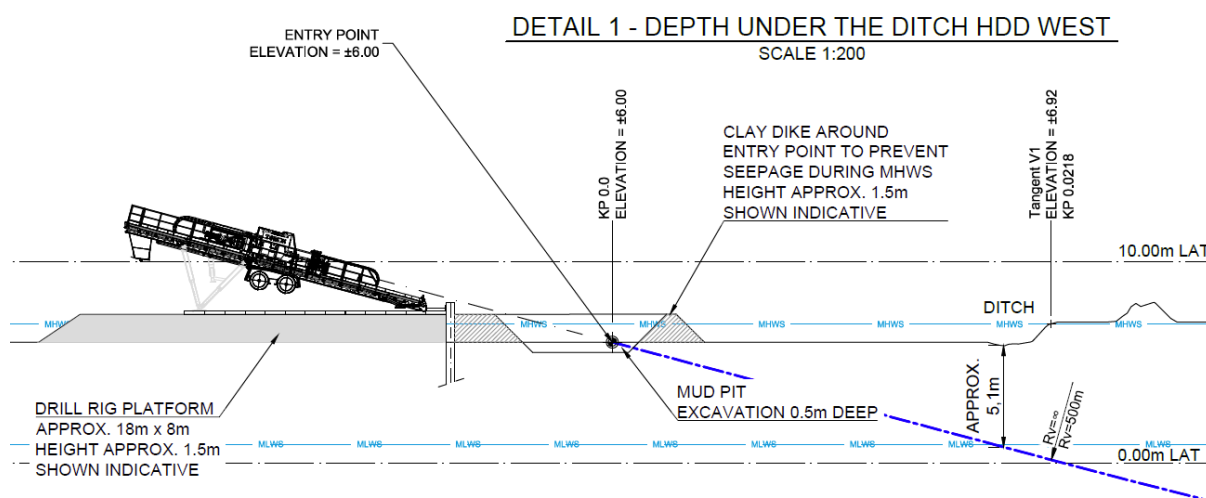

Figure 2-3 Indicative onshore rig and clay dykes.

2.1.2 Drilling

2.1.2.1 Pilot hole drilling

After the rig-up is completed, the HDD will commence (see Figure 2-4 (Steps 1 and 2)). Drilling mud (Bentonite) will be pumped down the drill string to break up and flush the material in front of and around the jet bit and flow back via the drilled hole to the mud pit at the entry site. Standard drilling mud additives may be used; the technical data sheets for these are included at Appendix D of the HDD CMS. Cuttings are removed from the bore by the circulating drilling mud (Bentonite). The drilling mud will comprise of water and Bentonite (see Section 2.3). An optional part of the process is the use of a recycling unit. The drilling slurry (Bentonite mud and cuttings) will be transported towards the recycling unit via a mud pump. In the recycling unit the cuttings will be separated from the drilling slurry, allowing the drilling mud to be reused.

The drilling mud (Bentonite) is used for several purposes:

- Carrying the cuttings out of the borehole;
- Stabilising the borehole;
- Preventing cross contamination of sea water on the land section;
- Lubricating the drill string; and
- Cools the drill bit.

Periodic surface readings will be taken along the drill line to monitor the position of the drill head during the drilling operation to provide the exact position of the drill head and to advise the driller of the drilling line and steering requirements.

Parameters of drilling fluid will be monitored and registered on a regular basis throughout the drilling phases. Results will be registered in Bentonite reports.

Monitoring includes:
- Registering the amount of Bentonite added to the drilling fluid;
- Measuring the viscosity of drilling fluid and drilling sand;
- Measuring the percentage of sand in drilling fluid and drilling sand; and
- Measuring the specific weight of drilling fluid and drilling sand.

To reduce drilling mud losses on the seabed, the intention is that the pilot hole will be 'short stopped' and retracted. 'Short stopping' is the process whereby the drill does not punch out of the sea bed during the pilot drill or initial reaming process (see below Figure 2-4 (Step 3)). On the final ream the bottom hole assembly will be modified to enable the drill to break the surface (see Figure 2-4 (Step 4)).

2.1.2.2 Forward reaming

The purpose of the forward reaming is to enlarge the pilot hole in a number of phases to the desired diameter to allow the installation of the HDPE pipes. The number of ream phases will be decided on site depending on the ground conditions encountered during the pilot drilling. The reaming will follow directly after the pilot hole drilling (see Figure 2-4 (Step 3)). The reaming tools enlarge the hole to the desired diameter by cutting and/or flushing the stratum with drilling mud (Bentonite). The drilling mud (Bentonite) carries the cuttings from the borehole whilst also providing stability to the excavated profile.

The ream phases will be carried out from the rig side and so the reaming process will be forward, to enable the pilot hole to be short stopped.

2.1.2.3 Pre-Punch out

Prior to punch out, the offshore spread, including dive support, will mobilise, install temporary

moorings and moor on site. All Project vessels will be equipped with communication and lighting equipment in accordance with international navigational standards. Following installation of the moorings, the pipeline will be tied-off to the mooring anchor.

The HDD exit point will be excavated using a backhoe dredge (or similar) at the determined locations. The excavation pits will be a minimum of 5m wide x 75m long and 2.5m deep nearshore / 1.8m deep offshore. Pit dimensions may be up to 10 to 20% larger than these minimum values and side slopes may also be required for stability, depending on local access requirements and ground conditions. The excavation assessment in this report therefore considers 1,393m^3 as a precautionary worst-case volume ((1.8m to 2.5m) x 5m x 75m x 120% x 2 pits). The dredged materials will be side cast to use as backfill material following installation.

2.1.2.4 Punch out operation

During the final forward reaming phase, the drill assembly will be pushed upwards to punch-out within the exit point (see Figure 2-4 (Step 4)). This process is known as the punch out at the exit point. Drilling mud (Bentonite) will be released under pressure during the punch out process.

The HDD length will be approximately 1km. The two exit point locations will be determined during detailed design; however, they are anticipated to be within the area presented in Figure 2-1. This area is below MLWS and in silty gravel, sand, gravely sand or sandy gravel (Osiris, 2013) (TK Electrical System ES Volume 2, Chapters 2 and 4; Document Refs: 6.2.2.2 and 6.2.2.4).

Step 1: Drill spread mobilised, drill profile confirmed (dashed line).
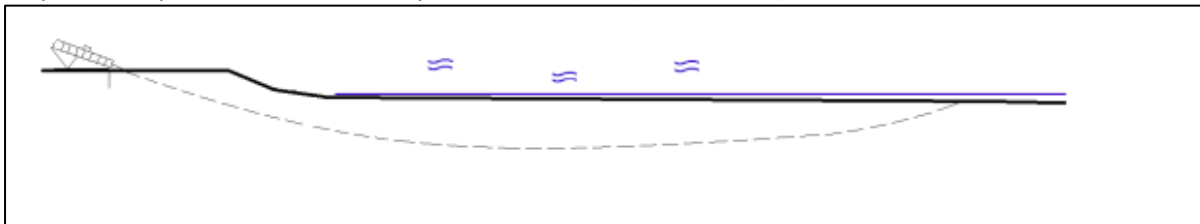
Step 2: Pilot drill – short stopped (solid drill line).
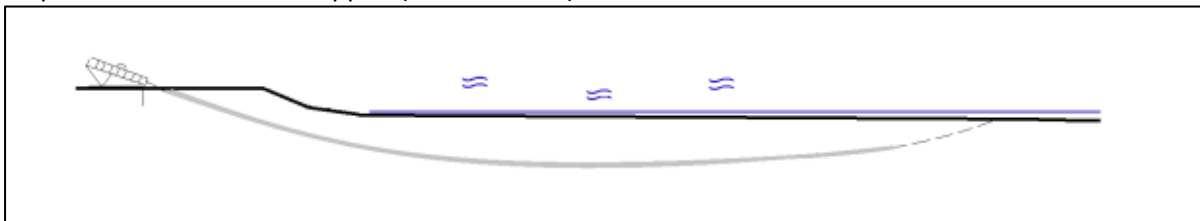
Step 3: Forward Ream phase (enlarged drill bore).

Step 4: Final Ream phase and punch out.

Step   5:   Pull   back   with   marine   spread   assistance.

Figure 2-4: Indicative HDD schematic storyboard (note: a jack-up barge will not be used during pull back)

2.1.3   Pull back

Following punch out, the HDPE pipes installation phase, known as pullback, shall be carried out from the offshore exit point (see Figure 2-4 (Step 5)). Once punch out is completed, the drilling assembly will be attached to the ~1km HDPE pipe and the pipe will be pulled through the HDD bore hole (Figure 2-5). Once the pipe installation is compl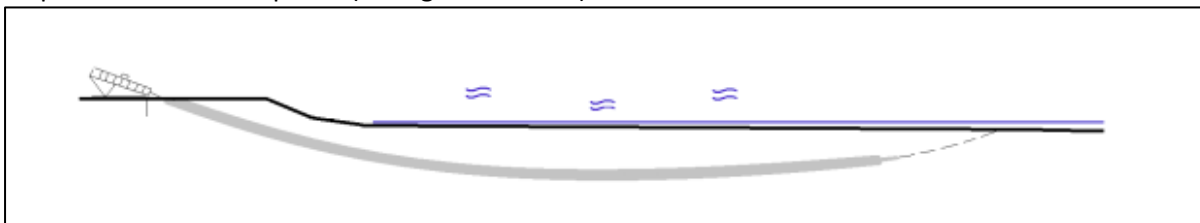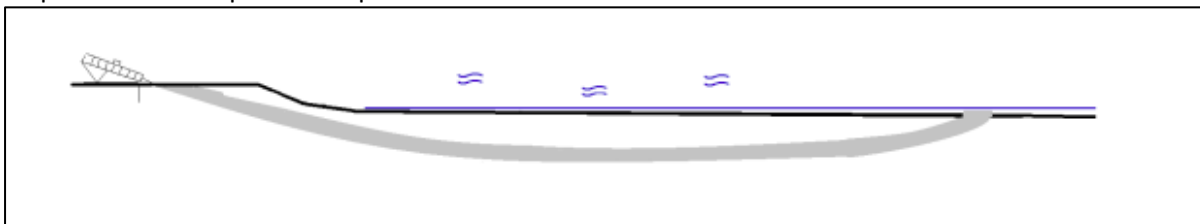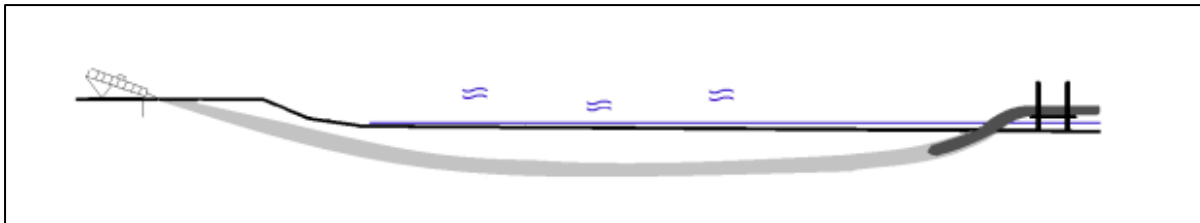ete, the end of the pipe will typically be closed with a blind flange until cable pull through. Rock bags) (or similar) will be laid on the pipe ends for stability. In addition to the rock bags an anchor with recovery rigging will be installed to the pipe end to stabilise pipe end.

During the phase between ducts being sealed and the cables installed the excavation pits may infill via natural sedimentation processes, such as bedload transport. Therefore, a mass flow excavator (MFE) may be required to remove the sediment from the excavation pits, prior to the removal of the rock bags (or similar). The MFE will be similar to those used on other Offshore Windfam projects, such as Westernmost Rough. It is assumed that the materials to re-fill the pit are likely to be of finer material than those originally excavated, given the nature of the sedimentary transport. A precautionary assumption of the percentage of the pit filled during this period is 75%. Therefore, this assessment has considered the use of a MFE to re-excavate the pits with a total of $1,045m^3$ ($1,393m^3$ x 75%) as a precautionary worst-case volume (as defined in Appendix A).

After the cable installation, the excavation pits at the exit points will be backfilled using a similar reverse method as for the excavation, i.e. backhoe dredger (or similar). If there is insufficient material available to backfill the excavation pits then Rock bags, or similar protection methods, may be used.

Drilling mud (Bentonite) will be released during this phase, see Section 2.3.
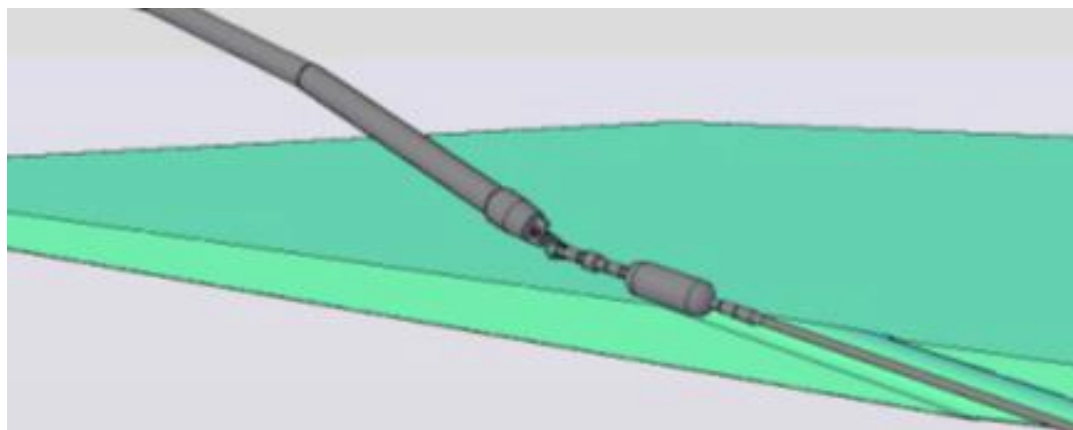
Figure 2-5: Diagram of the HDD pipe being pulled into the borehole

2.1.4   Repositioning

Upon completion of the pullback operation, the down hole assembly is removed from the pipeline and the rig and ancillary equipment will be repositioned to carry out the second drill. The same process will be followed for the second drill as outlined in Sections 2.1.2.1 - 2.1.3.

Upon completion of the second HDD, the equipment will be dismantled and de-mobilised.

2.2   Programme

The indicative durations of the proposed activities are presented in Table 2.1. These durations are

based on the assumptions of optimal ground and drill conditions and continuous working (7 days a week and 24 hrs working days (onshore (subject to agreement with the relevant authorities) and offshore). This sequence is indicative only and may be subject to change (i.e., the drilling at both locations may occur before the pull-back operations). The worst case considered in this assessment for the minimum time between drilling mud (Bentonite) releases from each of the two drills is four days, however this is considered unlikely as optimum drill conditions and continuous working will be required throughout the full drilling process.

Table 2.1: Indicative duration of proposed activities, the sequence may be subject to change.

ID	Description	Estimated Duration (days)	Cumulative Duration (days)
1	Site set-up and civil works	10	10
2	Mobilisation and HDD rig up	5	15
3	Drill 1st location	30	45
4	Offshore exit pit backhoe excavation (prior to or during Drilling)	16	-
5	Pull back 1st location	2	47
6	Reposition from 1st location to 2nd	1	48
7	Drill 2nd location	30	78
8	Offshore exit pit backhoe excavation (prior to or during Drilling)	16	-
9	Pull back 2nd location	2	80
10	Completion works offshore	4	-
11	Rig down and demobilisation	5	85
12	Civil site clear-up	10	95

Note: Should hard soils be encountered, the drilling duration (ID 3 and 7) maybe be extended if sub-optimal conditions are encountered. These durations may also be affected by weather downtime.

The final design, Construction Method Statements and programme, as required under Conditions (9) and (7) of the TK Electrical System dML will be supplied to the MMO for approval within the required timeframes prior to the commencement of construction.

It is anticipated that the proposed HDD works will be undertaken in Q1 to Q2 2019 with export cable installation anticipated in Q2 2020.

2.3   Bentonite

Bentonite (specifically sodium Bentonite as the chemical species under discussion) is a non-toxic, inert, natural clay mineral (<63μm particle diameter). Bentonite can be diluted with water and used as a drilling mud, lubricating the drill annulus and forming an impermeable filter cake that acts to control fluid loss. It has been used both for HDD works (including for offshore wind farm export cables) and in the oil and gas industry for the drilling of wells. Bentonite is on the List of Notified Chemicals approved for use in the marine environment and is classed as OCNS[2] group E, which is the group least likely to cause environmental harm. This is compliant with Condition 5(1) of the dML.

For the Project HDD works, the Bentonite will be mixed with water to create the drilling fluid. Standard drilling mud additives may be used; the technical data sheets for these are included at

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[2] Offshore Chemical Notification Scheme operated by Cefas - https://www.cefas.co.uk/cefas-data-hub/offshore-chemical-notification-scheme/hazard-assessment/

Appendix D of the HDD CMS. The Bentonite blend has a relative density of 2.4 and sinks in saltwater and, in still water, forms a lens underlying the water. As such the Bentonite, following the initial high pressure release, is anticipated to settle within the excavation pits.

Drilling mud (Bentonite) has the following functions:

- To remove cuttings from in front of the drill bit;
- To power the mud motor;
- To transport cuttings from the drill face through the annular space towards the surface;
- To lubricate the drill string during drilling phases and during pull back;
- To cool the reamers (cutting tools);
- To stabilise the hole; and
- To create a filter cake against the wall of the hole to minimise the risk of loss of drilling fluid or influx of groundwater penetration into the borehole.

Depending on the formation to be drilled through, the concentration is typically between 13 litres (30kg) and 35 litres (80kg) of dry Bentonite clay per m^3 of water. The maximum anticipated amount of Bentonite discharge per drill will be 30 tonnes, therefore the Project maximum anticipated total will be 60 tonnes (30 tonnes x 2 HDD bores / export cables).

Table 2.2: Anticipated Bentonite discharge volumes per drill

Phase	Anticipated amount of Bentonite discharge at sea per drill (tonne) (dry Bentonite only)
Pilot drill	0
Ream Phases	0
Punch out	10[†]
Pull back	20[≠]
Total	30

[†] suspended in 150 to 200m^3 water
[≠] suspended in 300 to 400m^3 water

2.4 Contingency Options

The method outlined above is the base case, however further survey works and engineering is required in order to finalise the planned works. Therefore, to ensure installation of the export cables the following contingency scenarios are presented:

- Contingency 1: Forward reaming, marine spread assisted by applying pull force on bottom hole assembly:
  - Drilling rods would be pushed out from the rig over the complete drilling profile;
  - After punch out the bottom hole assembly would be picked up by the supporting vessel;
  - The reamer would then be installed on rig side and pushed into the drilled hole;
  - During this process the vessel would assist by pulling the drill rods towards the sea, reducing the pushing forces required by the rig;

- o This contingency option would result in a greater release of drilling mud (Bentonite).
- Contingency 2: Backwards reaming (towards the shore) with marine spread assistance:
    - o The pilot drilling would punch out in to the seabed;
    - o The bottom hole assembly for the pilot drilling would be hoisted onboard a supporting vessel where it would be replaced by the reamer;
    - o The reamer would then be pulled towards the rig, so no buckling could occur;
    - o All drilling mud will be dispersed into the sea; and
    - o This contingency option would result in a greater release of drilling mud (Bentonite).

It is unlikely that Contingency 2 will be used in the installation process, however it is considered here as the worst-case scenario. These two different contingency methods will result in a greater volume of drilling mud (Bentonite) being discharged, see Table 2.3. As Contingency 2 provides the greatest potential discharge volume of Bentonite to the environment this is considered to be the worst case for the purposes of this assessment. However, as specified above, this is considered the least likely method of installation.

Table 2.3: Comparison of Bentonite release from contingency options per bore

Contingency Options	Total Bentonite discharge (tonne)
Baseline	30 (suspended in 450-600m^3)
Contingency 1	100 (suspended in 1,500-2,000m^3)
Contingency 2	200 (suspended in 3,000-4,000m^3)

2.5 Dune System Mitigation

This section outlines the in-built design and potential mitigation which will prevent the leaking of Bentonite beneath the dune system. The geology in which the drilling is proposed to be undertaken is non-porous (clay) and so is self-capping and will prevent Bentonite seeping into the strata surrounding the HDD bore. Furthermore, additives and composition of the drilling mud will be carefully considered for the conditions of the drill, and monitoring (as outlined in Section 2.1.2.1) will reduce the likelihood of breakouts under the dune system.

The surveys performed in the nearshore and across the dunes have confirmed that the stiff over consolidated glacial clays run as a consistent strata at an approximate depth of 1.5 to 2m LAT across the site and below the dunes. The current bore depth of the HDD below the dunes is anticipated to be at 10m LAT. This gives a cover of approximately 8m of high strength clay above the bore, before the base of the dunes.

The strength of the clay and the thickness of the strata is sufficient to resist the likelihood of frack out and the consequential loss of bentonite within the bore. The clay itself has a very low permeability and the addition of bentonite (and additives to the drill fluids), will ensure that a filter cake lines the bore and acts as an additional barrier to the migration of bentonite within the clay strata.

There is considered no additional risk to loss of drill fluid for any particular portion of the drill, whether that be the dunes or the exit box. As such the mitigations in place for the entirety of the drill will hold, regardless of the features above the bore. The purpose of these

mitigations is to ensure that the construction of the drill is performed successfully, this can only be achieved through a positive mud management system and drill design to ensure there is no loss of fluids. The supporting reports and the risk assessment documents for the HDD detail that no additional risk is considered under the dunes, over and above the mitigations already considered.

2.6 Assessment parameters

Assumptions and conservative parameters have been applied to this environmental assessment to ensure a precautionary approach. The assumptions applied in this assessment are:

- The minimum time between Bentonite releases from each of the separate HDD bores will be four days;
- The excavation pits will be within the proposed area (see Figure 2-1);
- The maximum drill period could potentially be longer if sub-optimal drilling conditions are encountered;
- The dredged material will be side cast for backfill;
- No additional material will be imported to backfill but concrete mattresses or rocks may be placed if required. These will not cause a reduction greater than 10% of the navigable depth (as required under Condition 1(4) of the dML);
- All Bentonite during the pull back phase will pool within the excavation pits;
- Two HDD bores are considered in the assessment (one bore and associated exit point per cable);
- The exit point locations will be at +/- 5m (LAT) water depth;
- Up to four vessels on site at any given time; and
- The worst case tidal conditions will be slack water which will result in the highest suspended sediment concentrations (SSC) and settling from suspension in the near-field. For the modelling assessment for the dispersion of Bentonite into the surrounding environment a current speed of 0.3m/s has been modelled.

The key parameters applied in this assessment are:

- The worst case total Bentonite volume released per bore will be 200 tonnes suspended in $3,000 – 4,000m^3$ of fresh water (see Section 2.4);
- 10% of the drilling mud will consist of fine drill cuttings;
- 10 tonnes will be forcefully released into the water column under pressure; and
- 190 tonnes will be released passively (i.e. not under pressure) under the worst case (Contingency 2). It is anticipated that the Bentonite will pool within the exit point and will subsequently be back-filled over.

The assessment seeks to discharge the requirement of Condition 14(1) of the dML which states *inter alia* that a risk assessment be undertaken for the purposes of assessing impacts on the designated bathing waters and the requirement of a seasonal restriction.

The final design detailed in the Construction Method Statements will seek to refine these assumptions further.

3   LEGISLATIVE REQUIREMENTS

3.1   Marine and Coastal Access Act 2009

The Marine and Coastal Access Act received Royal Assent on 12 November 2009. It introduced new planning and management systems for overseeing the marine environment, most notably through the requirement to obtain marine licences for works at sea (including the deposition or removal of any substance or object from the sea below Mean High Water). It created a strategic marine planning system that seeks to promote the efficient, sustainable use and protection of the marine environment, guided by the Marine Policy Statement and a series of Marine Plans.

The Marine and Coastal Access Act 2009 provides the framework for a marine licencing system, which is administered by the Marine Management Organisation (MMO). The Act also amended certain provisions of the Planning Act 2008. It inserts a new Section 149A 'Deemed Consent under a marine licence' in the Planning Act which enables any applicant for a DCO to seek within that DCO a deemed marine licence for operations carried out below the MHWS tide level wholly in England, and in waters adjacent to England up to the seaward limits of the territorial sea, and (for England and Wales) the UK Renewable Energy Zone (REZ).

There are no Marine Conversation Zones (MCZs) present within the cable corridor. The closest MCZ is Silver Pit, which borders the TK Array Order Limits to the west of the Project, which is a recommended MCZ (rMCZ) but has not currently been brought forward in Tranche Three (2015-2017) for designation. Therefore, this site has not been considered further in this environmental assessment of the proposed works.

This document is intended to provide the regulatory authorities (and their statutory advisers, where relevant) with the necessary supporting information to justify that an additional Marine Licence or variation to the existing deemed Marine Licence is not required. Furthermore, there is no requirement for an MCZ assessment.

3.2   The Environmental Impact Assessment Directive

Environmental Impact Assessment (EIA) is a tool for systematically examining and assessing the impacts of a development on the physical, biological and human environment. This process allows management and mitigation measures to be identified to ensure the development is sustainable.

The legislative framework for EIA is provided by European Directive 2011/92/EU (the EIA Directive), which codified the earlier European Directives 85/337/EEC, 97/11/EC and 2009/31/EC. The EIA Directive requires that EIA be undertaken in support of an application for development consent for certain types of project.

For projects which require development consent under the Planning Act 2008, the requirements of the EIA Directive have been transposed into UK legislation by the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009. These regulations are referred to in the Environmental Statement as 'the 2009 EIA Regulations (as amended)'. The TK Array and Electrical System ESs applied the 2009 EIA Regulations.

After the time of writing the TK Array and Electrical System ESs, the Council of the European Union adopted on 14 April 2014 a directive amending directive 2011/92/EU on the

assessment of the effects of certain public and private projects on the environment (PE-CO_S 15/14, 7927/14 ADD 1). Directive 2014/52/EU amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on environment was brought into force on 15th May 2014, hereafter referred to as the 2017 EIA Regulation.

The 2017 EIA Regulations set out the requirements and provisions for screening (deciding if an EIA is required), scoping (setting out the scope for the EIA) and the submission of an Environmental Statement that reports the EIA process and its findings. Under the 2017 EIA Regulations, certain projects are considered as 'EIA developments', and require an EIA as part of the application for a DCO. TKOWFL submitted an ES as part of the DCO application for both the Array and the Electrical System. This report has been informed by the relevant information and findings of the TK Array ES.

The assessment of the proposed activities (release of drilling mud/Bentonite below MLWS) does not constitute the need for an EIA under the EIA Directive, and therefore the proposed works are screened out from the requirement for an EIA.

3.3   The Habitats Directive

EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (known as the Habitats Directive) is intended to protect biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species listed in the Annexes to the Directive at a favourable conservation status. It provides for robust protection for those habitats and species of European importance.

EC Directive 2009/147/EC on the conservation of wild birds (known as the Birds Directive) provides a framework for the conservation and management of, and human interactions with, wild birds in Europe. It sets broad objectives for a wide range of activities.

In England and Wales, the Habitats Directive is implemented under the Conservation of Habitats and Species Regulations 2017 (the Habitats Regulations) and the Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2017. The Marine Habitats Regulations transpose the Habitats Directive and the Birds Directive into national law. The provisions of the Birds Directive are implemented through the Wildlife and Countryside Act 1981, the Habitats Regulations and the Offshore Marine Conservation (Natural Habitats & c.) Regulations 2017, as well as other legislation related to the uses of land and sea.

Under this legislation a network of protected areas (the Natura 2000 network) has been established. These are Special Areas of Conservation (SACs), for habitats and species, and Special Protection Areas (SPAs), for birds. The Habitats Regulations require that, where the possibility of a likely significant effect on a Natura 2000 site cannot be excluded (either alone or in-combination with another plan or project), a competent authority must undertake an Appropriate Assessment as part of the Habitats Regulations Assessment (HRA) process. The Habitats Regulations state that it is the developer's responsibility to provide sufficient information to the competent authority to enable them to assess whether there are likely to be any significant effects and to enable them to carry out the appropriate assessment, where necessary.

The proposed offshore works associated with the HDD (and the landfall) are within the Greater Wash Special Protected Area (SPA). The qualifying features of this European Site of relevance to the proposed works are:

- *Gavia stellata*; Red-throated diver (Non-breeding);

- *Hydrocoloeus minutus*; Little gull (Non-breeding); and
- *Sterna sandvicensis*; Sandwich tern (Breeding).

The presence of vessels and the associated disturbance has been assessed within the TK Electrical System ES. This assessment determined a very low magnitude and negligible sensitivity to the assessed activities; therefore, no significant effect was determined. The HDD works require a small number of vessels (up to four at any one time) and a low number of associated vessel transits to and from site, all of which are accommodated within the maximum numbers assumed for the purposes of the TK Electrical System ES. As all vessel movements associated with the HDD works therefore fall within the original consent envelope, no additional assessment of disturbance from vessels has been undertaken in this Environmental Information Report.

Due to the short term nature of the construction works, the absence of any ongoing effect during the operational phase and very low densities of red-throated divers (RTD) recorded within and around the Order Limits (plus 2km buffer) area, it is was determined in the TK Electrical System ES (Volume 2, Chapter 3, Document: 6.2.2.3) there will be no likely significant effect on the RTD population when the worst case was assessed for the activities of the entire Project. Specifically, the TK Electrical System ES identified no effect on the Outer Thames Estuary SPA or the future Greater Wash SPA either alone or in-combination.

RTD may be presented in the location of the proposed works, however they are typically found further offshore. The potential effects of the release of drilling mud (Bentonite) will be both highly localised and short term in nature. Therefore, no effect on the RTD population is anticipated either directly or indirectly of the proposed works. The release of drilling mud (Bentonite) does not have the potential to impact on ornithological receptors; as such there will be no Likely Significant Effect (LSE) on the qualifying features as a result of these activities. Therefore, there is no risk to the conservation objections of the Greater Wash SPA.

There is an absence of effect-receptor pathway on any Natura 2000 sites, beyond the Greater Wash SPA. A conclusion of no Likely Significant Effect on the qualifying features of any Natura 2000 site is therefore made.

The assessment of the proposed activities (release of drilling mud (Bentonite) below MLWS) does not constitute the need for a HRA under the HRA Directive, and therefore the proposed works are screened out from the requirement for a HRA.

3.4   The Water Framework Directive

The European Union (EU) Water Framework Directive (WFD) (2000/60/EC) was established in 2000 in order to provide a single framework for the protection of surface waterbodies (including rivers, lakes, coasts (up to one nautical mile) and estuaries) and groundwater. Each waterbody has an assigned ecological and chemical status. The ecological status is assigned by considering the biological, hydromorphological, chemical and specific chemicals. The different status categories are:

- High;
- Good;
- Moderate;
- Poor; or
- Bad.

Monitoring of the aquatic environment in relation to physical, chemical and biological parameters commenced in 2006 with a view to ensuring a 'good ecological status' of all surface waterbodies. Chemical and biological Environmental Quality Indicators are used, and a programme of measures is implemented in order to improve surface waters that do not meet the required status.

The WFD's objective of a "Good chemical status" is defined in terms of compliance with all the quality standards established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritisation mechanism for hazardous chemicals. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances.

The WFD's objective of a "Good ecological status" also requires certain chemical conditions. The chemical requirements include the achievement of environmental quality objectives for discharged Priority Substances and for any other substances liable to cause pollution and identified as being discharged in significant quantities.

The WFD seeks to reduce Priority Substances (20 are Priority Substances and 13 are Priority Hazardous Substances = 33 in total) in the marine environment through the use of the Environmental Quality Standards Directive (EQSD) for discharges and outfalls. Priority substances include benzene, nickel and lead. Bentonite is not a priority substance.

This assessment is reliant on identifying those effects that are non-temporary. For the purposes of this assessment, non-temporary is defined as:

"Non-temporary: A period of time that is greater than the recommended monitoring period interval as stated by the WFD (2000/60/EC)."

The proposed HDD works are within the Yorkshire South/ Lincolnshire coastal WFD waterbody, see Figure 3-1.
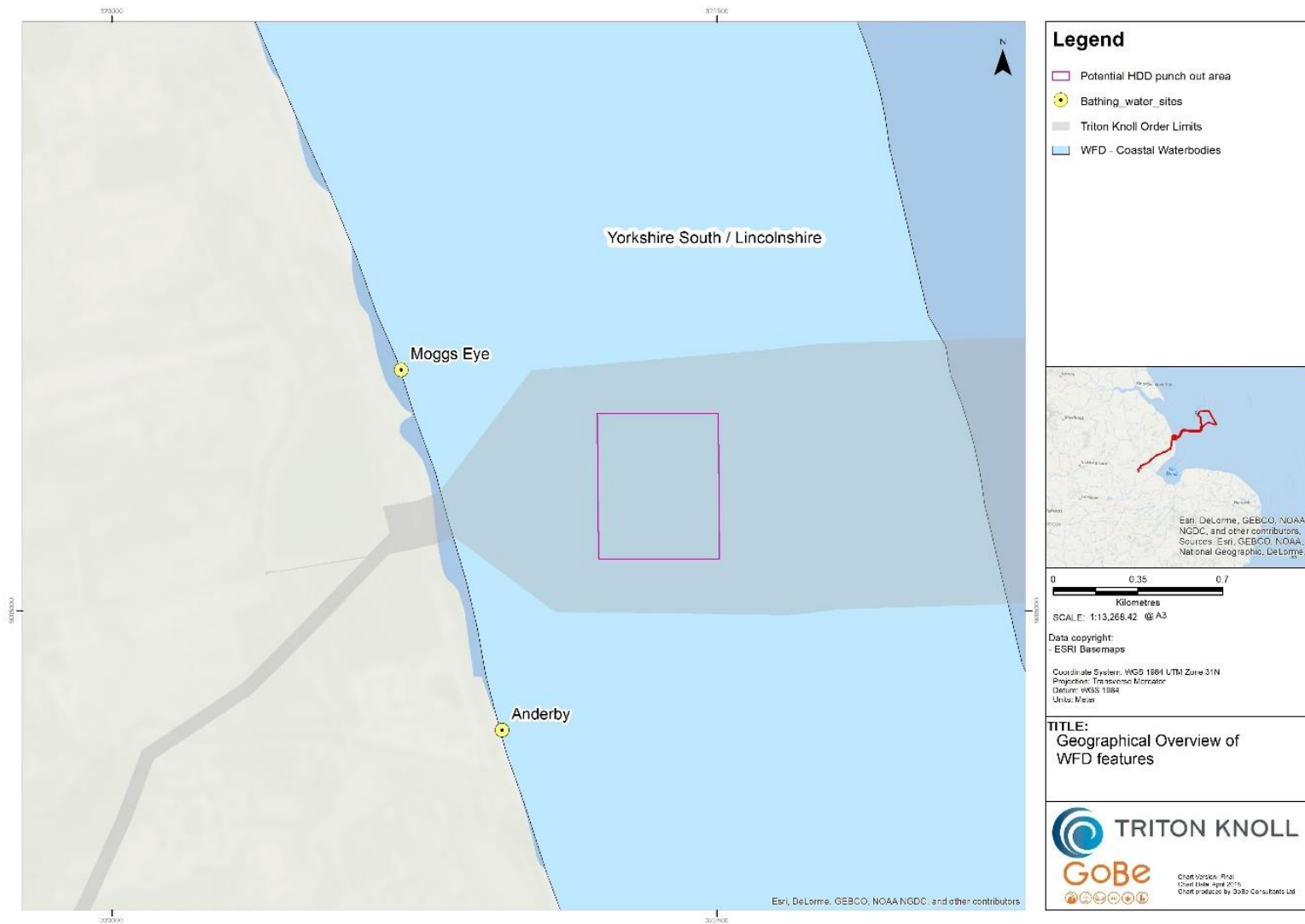
Figure 3-1: Geographical Overview of WFD features

3.4.1   The revised Bathing Water Directive

The EU's revised Bathing Water Directive (rBWD) (2006/7/EC) came into force in March 2006 and replaces the current Bathing Water Directive (cBWD) (76/1160/EEC). The rBWD provides more stringent standards than the cBWD and places an emphasis on providing information to the public.

The rBWD has four different classifications of performance, these are:
- Excellent – the highest, cleanest class;
- Good – generally good water quality;

- Sufficient – the water meets minimum standards; and
- Poor – the water has not met the minimum required standards.

Pollution at designated bathing waters is defined as "contamination which affects bathing water quality and presents a risk to bathers' health from any of the following:

(a) intestinal enterococci or *Escherichia coli*;
(b) cyanobacterial proliferation;
(c) a proliferation of macro-algae or marine phytoplankton;
(d) waste, including tarry residues, glass, plastic or rubber" (SoS, 2013)

The Environment Agency (in England) measures, monitors and reports each of these pollutants. The types of bacteria (*Escherichia coli* (*E.coli*) and Intestinal Enterococci (IE)) may indicate the presence of pollution, mainly from sewage or animal faeces. An increase in the concentrations of these bacteria indicates a decrease in water quality.

The status of the designated bathing waters within 2km of the TKOWF Order Limits are -

- Mogg's eye (Excellent (2014 – 2017)); and
- Anderby (Excellent (2014 – 2017)).

The minimum distance from the designated bathing waters are approximately 830m and 810m from the boundary of the proposed exit point area (see Figure 3-1).

Bentonite does not fall under the described categories of pollutants (intestinal enterococci, *E. coli*, cyanobacteria; macro-algae, marine phytoplankton or waste) for bathing waters. It is acknowledged that there may be a temporary reduction in water clarity (see Section 4.2) at both Moggs Eye and Anderby bathing waters, however clarity is not an indicator or performance standard of bathing water quality under the rBWD. Therefore, no further consideration of bathing water performance, at these two designated bathing waters, is considered in this Environmental Information Report. However, the reduction of water clarity has been considered for the Yorkshire South/ Lincolnshire coastal WFD water body in Section 4.2. Full consideration of the bathing water Condition from the TK Electrical System dML is provided in Table 3.1.

Table 3.1: Consideration of Condition 14 of TK Electrical System dML

Condition	Consideration
A scheme must be provided if works are proposed to be undertaken within the Bathing Season (15th May to 30th September).	This Environmental Information Report is the provision of this scheme. The works are proposed to be undertaken in Q1 and Q2 2019, so may overlap with the beginning of the Bathing Season.
The scheme must include an assessment of any works in the intertidal area (with particular focus on the potential bacti issues that may be caused by disturbed sediments).	The proposed works will be in the subtidal area and are no longer proposed to be in the intertidal area (as assessed in the TK Electrical System ES). The works will be discreet in nature. The proposed works will not disturb sediments within the intertidal area. The sediment disturbance will be confined to the subtidal area and will be sufficiently offshore as not to interact with sediments contaminated with bacteria. The currents advecting the plume are aligned parallel to the coast and so it is reasonable to assume that the plume will largely remain a similar distance offshore and therefore may not overlap the nearby (nearshore) designated bathing waters areas. If the plume experiences sufficient lateral diffusion to reach the adjacent shoreline, then the corresponding SSC will be very low (within the range of naturally occurring values) (see Appendix B: Investigation into the Fate of Drill Fluid and Drill Arisings). Therefore, the disturbed sediments are not anticipated to affect the status of the bathing water quality at the designated bathing waters.
The scheme must identify measures to be implement to mitigation and identified risks to ensure the status of the BW quality under the rBWD is not impacted.	No risks to the status of bathing waters has been identified as a direct or indirect result of the proposed works.

3.5   Natural Environment and Rural Communities (NERC) Act 2006

The Natural Environment and Rural Communities (NERC) Act came into force on 1 October 2006. Section 41 (S41) of the Act requires the Secretary of State to publish a list of habitats and species which are of principal importance for the conservation of biodiversity in England. The list has been drawn up in consultation with Natural England, as required by the Act.

The S41 list is used to guide decision-makers such as public bodies, including local and regional authorities, in implementing their duty under Section 40 of the Natural Environment and Rural Communities Act 2006, to have regard to the conservation of biodiversity in England, when carrying out their normal functions.

Fifty-six habitats of principal importance are included on the Section 41 list. These are all the habitats in England that were identified as requiring action in the UK Biodiversity Action Plan (UK BAP) and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework.

The two Section 41 list habitats of potential relevance to the proposed works (use of HDD) are:

- Peat beds; and
- *Sabellaria spinulosa* reef habitat.

The surveys undertaken by Osiris (2013) (Figure 3-2) indicate that the closest possible potential *S.spinulosa* reef structure is approximately 5km from the proposed HDD exit point locations.

Pre-construction surveys will be undertaken to identify areas of *S.spinulosa* to inform the siting of Project infrastructure. Pre-construction surveys for TKOWF will cover the offshore area within which construction is expected to take place and will be designed with the purpose of confirming the presence or absence of any Annex I (within a designated site) or NERC reef habitat (outside of a designated site).

A draft Annex I Mitigation Scheme (Document Ref: 2505-TKN-CON-D-RA-0002) has been prepared on behalf of TKOWFL which has been submitted to Natural England, and exclusion buffer zones identified. The proposed works outlined in Section 2 will be subject to the measures outlined and agreed with the MMO and Natural England in the final mitigation plan.

The geophysical survey work carried out by Osiris (2013a, b) identified possible exposed peat beds in the intertidal and nearshore sublittoral (Figure 3-2). These areas are outside the proposed HDD exit point area. The TK Electrical System ES noted that due to the uncertainties about the underlying geology for the purpose of the assessment, peat and clay outcrops were assumed to be continuous across the cable corridor. Therefore, the proposed exit point area was considered within the ES for direct disturbance from construction activities. Direct disturbance of these habitats was assessed within the TK Electrical System ES and found to be of very high sensitivity, very low magnitude and therefore minor impact and so not considered to be significant. The proposed works are considered to be within the identified Rochdale Envelope, previously assessed, and therefore not considered to be considered significant.

It is therefore predicted that there will be no significant adverse effect from the proposed works, on Section 41 habitats of principle importance, and no further consideration to Section 41 habitats of principle importance has been considered in this report.
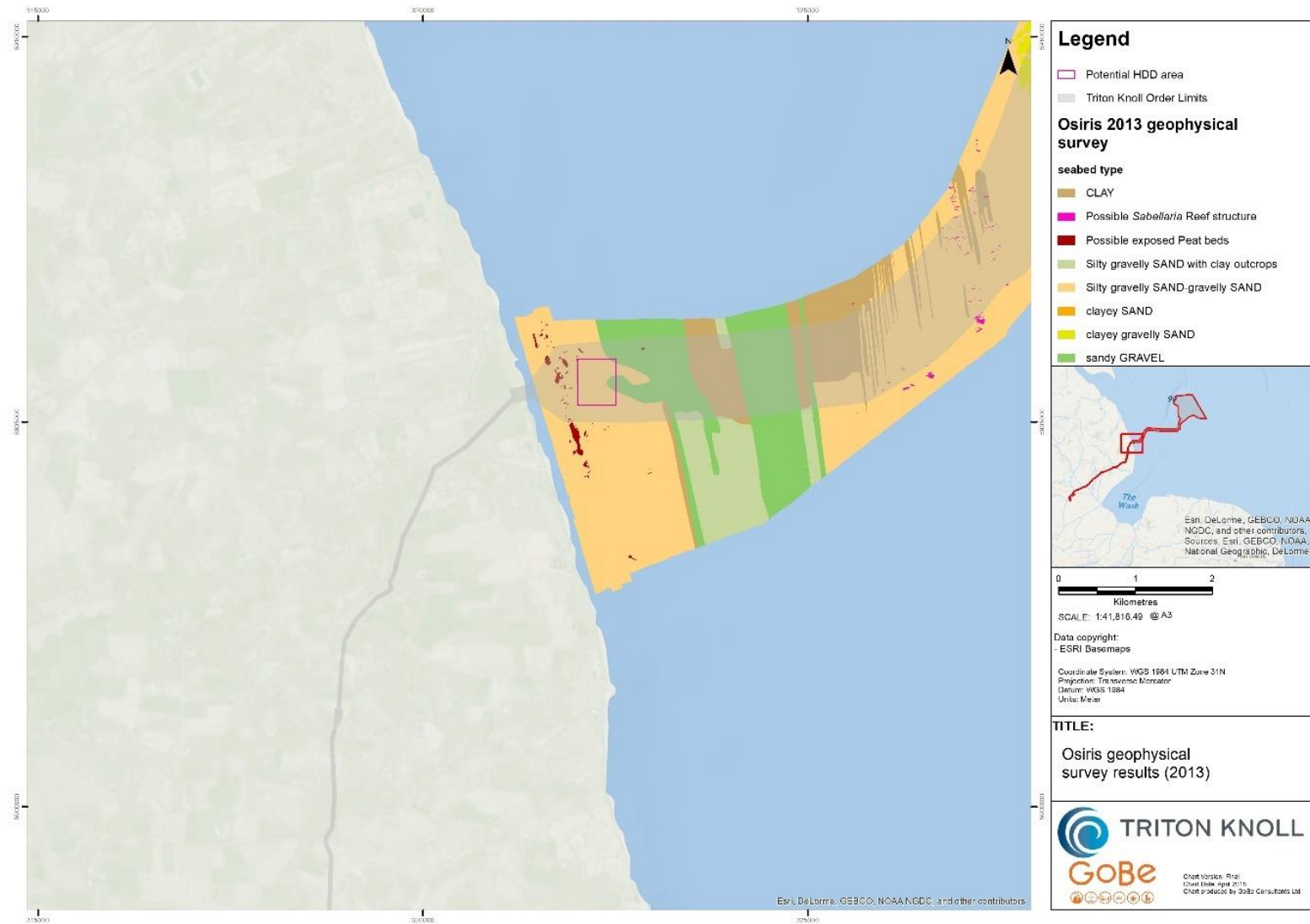
Figure 3-2: Osiris geophysical survey results (2013)

4   ENVIRONMENTAL ASSESSMENT

This Section provides an initial screening of the potential effect-receptor pathways in order to define the relevant receptors for further assessment. For those potential effects screened in, an assessment is provided of the potential risk of an effect on the given receptor being greater than those already predicted within the ES. This document includes a summary of the baseline and characterisation information presented within the ES and other sources, and where relevant and appropriate, draws on the effects assessed within the ES.

This Environmental Information Report seeks to provide the regulatory authorities (and their statutory advisers, where relevant) with sufficient information to scope out any additional effects identified outside of those assessed within the existing TK Electrical System ES and therefore to justify that an additional Marine Licence or variation to the existing deemed Marine Licence is not required.

Following the initial screening in Section 4.1, Sections 4.2 to 4.3 present the baseline characteristics of the receiving environment within the area of proposed works (and the surrounding area, where relevant), followed by an environmental assessment of the screened-in effects.

The assessment criteria and EIA terms used in the ES have been adopted for the purposes of this document. Further information and detail is presented within Volume 1: Chapter 3 of the ES – Approach to EIA Document (Reference: 6.2.1.3).

A summary of the environmental assessment is presented in Section 4.5.

4.1   Screening of Potential Effects

This Section presents the screening exercise where the relevant potential effects are identified, followed by consideration of whether there is an effect-receptor pathway that may result in a significant effect. Where there is no pathway for a potential effect to interact with a receptor, the effect is screened out of this Environmental Information Report. Where a pathway exists, but receptors are screened out a justification is provided.

The following offshore environmental effects have been screened out of this further assessment as they sit within the Rochdale Envelope already assessed within the TK Electrical System ES. Therefore, they have already been fully considered and are consented under the existing TK Electrical System dML:

- Vessel disturbance/ collision risk for marine mammals;
- Vessel disturbance on marine ornithology; and
- Direct disturbance of benthos and NERC habitats (see Section 3.5).

In order to minimise disturbance on Red-throated divers the Project will adhere to the best code of practice where possible, the details of which are provided in the HDD Construction Method Statement.

Whilst Bentonite is an inert and approved waterbased drilling mud, there are two potential environmental impacts associated with the release of Bentonite within the marine environment.

These are smothering of sessile benthic organisms and increased levels of suspended sediment concentrations (SSC). The excavation of sediments for the exit points will also result in an increase in SSC. In addition, direct disturbance of the seabed and increase in SSC arising from the excavation of the pits for the two HDD exit in the subtidal area has the potential to impact archaeological material which may be buried within the seabed. The identified receptors for this Environmental Information Report are presented in Table 4.1.

Table 4.1: Screening outcomes from the proposed works

Receptor	Effect		
	Smothering from increased suspended sediment deposition	Increased levels of suspended sediment concentrations (SSC)	Direct Disturbance
Water Quality	✗	✓	✗
Benthic Ecology	✓	✗	✗
Marine Archaeology	✗	✓	✓

✓ = screened in for further assessment; ✗ = screened out for further assessment

4.2   Marine Water Quality

4.2.1   Baseline

SSC varies within the study area, as considered within the TK Electrical System ES, between the nearshore and offshore areas and exhibit a seasonal variation. Throughout the year there is a strong east to west gradient in SSC, with the greatest concentrations observed at the coast in inshore/ nearshore areas. During winter months the surface suspended particulate matter (SPM) concentrations are typically around 10 mg/l in the offshore area of the cable corridor, increasing to ~60 mg/l in the inshore/ nearshore Area (Annex 6.1 Physical Processes Technical Baseline Report; ABPmer, 2014). During summer months, SPM concentrations along the corridor are typically in the range 5 to 10 mg/l.

Substrates in the export cable route corridor can be classified into coarse sediment, sand, and mixed sediment. Sediments alternate between sandy (associated with sandbanks), with coarse or mixed sediments in the deeper water between the sandbanks. The seabed is typically tide-swept, with mobile sediment and scour.

The two exit points for HDDs will be below MLWS and in silty gravel, sand, gravelly sand or sandy gravel.

Water depths along the export cable route corridor are generally less than 20 m LAT (Gardline, 2009; Osiris, 2013a). Tidal currents in this region generally follow the orientation of the coastline and flow in a southerly direction during the flood tide and in a northerly direction during the ebb tide. With the exception of the nearshore area immediately adjacent to the landfall, which has maximum spring current speeds of around 0.6 m/s, at all locations along the export cable corridor peak spring flows exceed 0.8 m/s and in places exceed 1.0 m/s. The status of the Yorkshire South/ Lincolnshire coastal water body overall status of Moderate (Ecological = Moderate; Chemical = Good). It is a

heavily modified water body, including for coastal defences.

4.2.2   Environmental Assessment – Increased Suspended Sediment Concentration

4.2.2.1   Release of Bentonite

The release of Bentonite will temporarily increase SSC. However, as it is a clay-based substance it can be rapidly dispersed in high-energy environments and as such the local SSC will decrease within one tidal cycle.

Appendix B (Investigation into the Fate of Drill Fluid and Drill Arisings) presents the specific dispersion modelling undertaken for the proposed activities to understand how the Bentonite will behave both under the punch out (release under pressure) and a gradual release scenario (where the Bentonite will be constrained within the exit points). Appendix B: Investigation into the Fate of Drill Fluid and Drill Arisings provides the full technical detail of the modelling scenarios. Sections 4.2.2.1.1 and 4.2.2.1.2 have been informed by the findings of the modelling assessment.

4.2.2.1.1   Under pressure

Based on the worst case scenario release of 10 tonnes of Bentonite under pressure during the punchout/backward ream for Contingency 2, the initial concentration at the location of the punch out will be approximately 65,000 mg/l. However, within 150 m (laterally) of the source the concentration would rapidly reduce to 44 mg/l. This is comparable to the SSC recorded within the winter months. Therefore, given the strong concentration gradients across the plume it can be expected that within one tidal cycle, the contribution of the Bentonite to the local background levels of SSC will be negligible. Given the very short term, spatially discrete nature of the effect, and that there will be no measurable interaction between the plumes of Bentonite from each of the two HDD bores, it is reasonable to conclude that the effect is temporary and not likely to result in an effect greater than that already predicted on the water body, or the bathing water locations of relevance.

These findings are in line with those assessed within the TK Electrical System ES for cable installation within this area and as such the revised HDD methodology is not considered to result in an effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale of effect than previously assessed and is a greater distance from the designated bathing waters.

Therefore, the increased SSC resulting from the release of Bentonite will not result in a significant (non-temporary) effect on water quality receptors. There is no prediction for deterioration of the status of the South Yorkshire/ Lincolnshire Coastal WFD water body or local designated bathing waters. Therefore, there is no change to the original ES conclusion of a not significant impact on marine water quality as a result of the revised HDD methodology.

4.2.2.1.2   Gradual release

Under the gradual release scenario (where Bentonite will not be released under pressure), there will be a smaller plume with much lower concentrations of suspended sediments present. Within 1 m of the release location, the SSC will be 463 mg/l. However, this will rapidly disperse and be 5 mg/l within 10 m. This is consistent with typical summer SPM concentrations. Therefore, it can be expected that within one tidal cycle the contribution of the Bentonite to the local background levels of SSC will be negligible. As with the initial high pressure release phase of Bentonite, given the very short term, spatially discrete nature of the effect, and that there will be no measurable interaction between the plumes of Bentonite from each of the two HDD bores, it is reasonable to conclude that the effect is temporary and not likely to result in a significant effect on the water body, or the bathing water locations of relevance.

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These findings are in line with those assessed within the TK Electrical System ES for cable installation within this area and as such the revised HDD methodology is not considered to result in an effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale of effect than previously assessed and is a greater distance from the designated bathing waters.

Therefore, the increased SSC resulting from the release of Bentonite will not result in a significant (non-temporary) effect on water quality receptors. There is no prediction for deterioration of the status of the South Yorkshire/ Lincolnshire Coastal WFD water body or local bathing waters. Therefore, there is no change to the original ES conclusion of a not significant impact on marine water quality as a result of the revised HDD methodology.

4.2.2.2   Increased SSC from offshore exit point excavation

The proposed excavation of two exit points will result in highly localised and discreet increases in SSC, through the disturbance of the existing sediments. The sediments within the proposed exit point area (below MHWS) consist of sands and gravels which will rapidly fall out of suspension, see Figure 3-2.

These findings are in line with those assessed within the TK Electrical System ES (Volume 2, Chapter 2: Marine Physical Environment) for cable installation within this area. The Marine Physical Environment assessment concluded the significance of the increase in SSC from cable installation (0.5 m (width) x 66 km (length) x 1.5 m (depth) x 6 (cables)) to be negligible. Site specific modelling was undertaken for the TK Electrical System ES and concluded that the materials would be constrained primarily to the nearfield or immediate far field based on the composite of sediments disturbed.

The revised HDD methodology is not considered to result in an effect which exceeds that already predicted for the similar works for cable installation considered in the TK Electrical System ES; and is determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale of effect than previously assessed and is a greater distance from the designated bathing waters (being in the subtidal rather than the intertidal zone).

4.2.2.3   Increased SSC from offshore exit point re-excavation

Appendix A of this Environmental Information Report provides an investigation into the use of the MFE to remove sediment from the offshore exit pits prior to cable installation through the HDPE pipes. The investigation concludes that the disturbance of sediment by the planned MFE dredging operations will result in a localised and temporary plume of elevated SSC, comprising the naturally present sediment that is both from, and is being returned to, the ambient sediment transport regime. The plumes of SSC will be advected in the direction of the ambient tidal currents, which are aligned parallel to the coast and therefore are likely to remain a similar distance offshore. The plume would be dispersed to relatively low concentrations within hours of the cessation of dredging and to below background concentrations within a few tidal cycles.

The revised HDD methodology is not considered to result in an effect which exceeds that already predicted, for the similar works for cable installation considered in the TK Electrical System ES; and is determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale of effect than previously assessed and is a greater distance from the designated bathing waters (being in the subtidal rather than the intertidal zone).

Therefore, the increased SSC from the disturbance of sediments will not result in a significant (non-temporary) effect on water quality receptors. There is no prediction of the deterioration of the status of the South Yorkshire/ Lincolnshire Coastal WFD water body or local bathing waters. Therefore, there is no change to the original ES conclusion of a not significant impact on marine water quality as a result of the revised HDD methodology.

4.3 Benthic Ecology

4.3.1 Baseline

The most widespread benthic biotopes mapped for the region includes SS.SCS.CCS.PomB (*Spirobranchus* (*Pomatoceros*) *triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles) across the west of the study area and SS.SSa.IFiSa.NcirBat (*Nephtys cirrosa* and *Bathyporeia spp.*in infralittoral sand), further offshore. Both habitats are mapped in small patches within 5km of the Order Limits (TK Electrical System, Volume 2, Chapter 4, Reference: 6.2.2.4).

A number of benthic biotopes have been identified along the cable route. The middle section of the cable route is characterised by well sorted medium and fine sands subject to tidal and/or wave action; communities were typically impoverished, with infaunal biotopes characterised by polychaetes (e.g. *Nephtys cirrosa*) and crustaceans (e.g. *Bathyporeia spp.*) with sparse epifaunal communities. Within the inshore area, infauna is relatively sparse due to exposure to wave action and tidal movement, although with a significant epifaunal community, dominated by *Flustra foliacea* (SS.SCS.ICS). In terms of biotopes, within the intertidal (landfall area) is classified as a mosaic of rather impoverished variants of LS.LSa.FiSa.Po (Polychaetes in littoral fine sand), the sub-biotope LS.LSa.FiSa.Po.Ncir (Nephtys cirrosa dominated littoral fine sand), and LS.LSa.MoSa (Barren or amphipod-dominated mobile sand shores), the latter being more prevalent in run-off areas.

4.3.2 Environmental Assessment – Smothering

4.3.2.1 Release of Bentonite

The release of Bentonite has the potential for smothering of benthic species due to the propensity of the Bentonite to aggregate and settle to the lowest point when not in suspension. Smit *et al.* (2008) carried out a literature review of the impacts of discharges (i.e. drilling muds) on the marine environment and in particular on the survivability of different species groups to corresponding impacts of discharges, specifically the impacts of:

- Suspended clays;
- Burial by sediment; and
- Changes in sediment grain size.

This study demonstrated that infaunal benthic species have a generally high level of resistance to all three factors including smothering. Using the data from the studies in the literature review, Smit *et al*. (2008) calculated the 50% hazardous level (HL50; using similar techniques to toxicology studies) for burial based on the escape potential of the species studied. Using this data, the average HL50 for burial for all the marine species groups was calculated as 5.4 cm (Smit *et al*., 2008). Table 4.2 shows the sensitivities to burial (i.e., smothering) and increased SSC for the dominant species for each biotope identified within the nearshore, below MLWS, surrounding the HDD works from the MarLIN sensitivities assessments[3] for each species.

The benchmarks for the assessments are as follows:

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[3] http://www.marlin.ac.uk/species/az/scientific - accessed 09/04/18

- Sensitivity to burial: burial to 5 cm depth for one month; and
- Sensitivity to increased SSC: 100 mg/l increase for one month.

Table 4.2: MarLIN Sensitivity Assessments

Biotopes	Sensitivity to smothering	Sensitivity to increased SSC
SS.SSa.IFiSa.NcirBat	Not Sensitive	Low
SS.SCS.CCS.PomB	Not Sensitive	Not Sensitive
SS.SCS.ICS	Not Sensitive	Not Sensitive
LS.LSa.FiSa.Po	Not Sensitive	Not Sensitive
LS.LSa.FiSa.Po.Ncir	Not Sensitive	Not Sensitive
LS.LSa.MoSa	Not Sensitive	Not Sensitive

Based on the behaviour of Bentonite as described above, it is expected that only the immediate local habitats and species need to be considered in terms of the potential for an adverse effect. This immediate area of effect is considered to be in the vicinity of the exit points within the nearshore area.

As shown within Table 4.2, none of the biotopes identified have a high sensitivity to either burial or increased SSC. As the concentrations will rapidly decrease laterally within the plume of Bentonite and will be within normal SSC ranges within the short distance for the release locations, it is considered that once re-suspended, the SSC concentrations will be within natural variation for the area. As noted previously, there will be no interaction between the two HDD plumes and whilst there may be some residual sediment within the zone of effect (i.e., within 150 m of the source) these are anticipated to be within background levels.

All the biotopes assessed are not sensitive to burial over the benchmark period of one month, which is highly precautionary given the short term nature of the predicted effect. Each of the biotopes identified above have either 'low' or are 'not sensitive' to increased SSC. The magnitude of the effect is considered to be low as it will be a short natured (hours to days) and localised effect. Given both the low sensitivity and the low magnitude, the effects on benthic ecology are considered to be negligible.

These findings are in line with those assessed within the TK Electrical System ES for cable installation within this area and as such the revised HDD methodology is not considered to result in an effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale of effect than previously assessed.

Therefore, the smothering from the release of Bentonite is not considered likely to result in a significant effect on benthic ecology receptors. There is no change to the original ES conclusion of a not significant impact on benthic ecology as a result of the revised HDD methodology.

4.3.2.2   Smothering from release of sediments during offshore exit point excavation

The excavation of cables within the subtidal zone and the impacts associated with these activities was assessed in the TK Electrical System ES within all relevant chapters. Benthic Ecology was assessed within the intertidal and subtidal ecology chapter (Volume 2, Chapter 4). The ES assessed

the impacts of jet trenching ~0.5m wide with an overall area of disturbed bed of 5m from the Remotely Operated Vehicles and side casting of the sediments. The total length of cables assessed was 396km (6 x 66km) within the subtidal which provides a maximum direct impact of 1.98km^2. The proposed excavation pit areas are a maximum of 5m wide but 75m long which is a comparable width and reduced length to that assessed within the ES. The excavation of the HDD pits is not considered to result in a direct effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant. It should also be noted that the reduction in export cable number (six to two) will result in a smaller area of direct disturbance than in the consented design envelope.

The proposed excavation of two exit points will result in highly localised and discreet increases in SSC, through the disturbance of the existing sediments. The sediments within the proposed exit point areas consists of sands and gravels which will rapidly fall out of suspension which may result in smothering of non-mobile benthic species. The maximum total volume per excavation pit to be side cast is 1,393m^3 during the initial excavation with the backhoe dredger.

As identified in Section 4.3.2.1, the biotopes assessed are not sensitive to burial over the benchmark period of one month, which is highly precautionary given the short term nature of the predicted effect. The magnitude of the effect is considered to be low as it will be a short natured (hours to days) and localised effect. Given both the low sensitivity and the magnitude the effects on benthic ecology are considered to be negligible.

The TK Electrical System ES assessed a secondary nearfield smothering impact on the subtidal seabed arising from the cable installation activities resulting in a maximum footprint of 2.86km^2 to a maximum depth of 1m. This footprint was calculated on a total volume of 48,500m^3 per cable trench being displaced (with six trenches in total). Given the widespread habitats, the low sensitivity of biotopes; and the temporary and localised nature of the effect the overall significance was deemed to be negligible.

These findings in this assessment are in line with those assessed within the TK Electrical System ES for cable installation within this area and as such the revised HDD methodology is not considered to result in an effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant. The revised HDD methodology has a reduced temporal and spatial scale than previously assessed.

4.3.2.3   Smothering from release of sediments during offshore exit point re-excavation

As presented within Appendix A, the finer sediment disturbed by the MFE dredging will be held in suspension for days to weeks or longer before settling. In this time, the individual grains will become dispersed widely over very large areas and so will not result in any measurable thickness of sediment accumulation or change in sediment type or texture. Sand sized or coarser sediment disturbed by the MFE dredging will be deposited more rapidly to the seabed around the HDD exit pits with the maximum likely distance for sand to be transported prior to deposition of 50 to 150m. The average thickness in which the sediment may accumulate is in the order of less than tens of centimetres. It is possible that the deposit from one pit may overlap spatially with that of the other, however, the distance between the pits would require a relatively large deposit length to achieve overlap. In this case, the combined average thickness of an overlapping deposit would remain small in absolute and relative terms.

As identified in Section 4.3.2.1, the biotopes assessed are not sensitive to burial over the benchmark period of one month, which is highly precautionary given the short term nature of the predicted

effect. The magnitude of the effect is considered to be low as it will be a short natured (hours to days) and localised effect. Given both the low sensitivity and the magnitude the effects on benthic ecology are considered to be negligible.

Therefore, the smothering from the disturbance of sediments is not considered likely to result in a significant effect on benthic ecology receptors. There is no change to the original ES conclusion of a not significant impact on benthic ecology as a result of the revised HDD methodology.

4.4 Marine Archaeology

4.4.1 Baseline

The archaeology and heritage baseline at the landfall and within the nearshore area of the cable route was established as part of the ES for the TK Electrical System. The ES chapter was supported by a desk-based assessment undertaken by Headland Archaeology (2014) which included a review of geophysical and geotechnical data acquired for the Project in 2012. This baseline was subsequently reassessed as part of a review undertaken by Wessex Archaeology (2016a) to inform the approach to mitigation during the pre-construction and construction phases of the development. An updated gazetteer of seabed features of archaeological interest was produced and included in the Written Scheme of Investigation (WSI) prepared for the scheme (Royal HaskoningDHV, 2018). The WSI also includes an updated assessment of the known and potential archaeological baseline below Mean High Water Springs (MHWS), including the intertidal zone, and the methodology for pre-construction site investigations and the delivery of mitigation. The implications of long HDD at the landfall have been considered with regard to the updated baseline and mitigation presented within this WSI.

The updated archaeological baseline concludes that the intertidal zone includes potential for the remains of eroding, and potentially in situ, submerged prehistoric land surfaces and palaeoenvironmental data, as well as artefacts from the Roman to modern periods, including maritime and aviation material that may be present on the foreshore (Royal HaskoningDHV, 2018).

4.4.2 Environmental Assessment

4.4.2.1 Direct Disturbance

Trenching within the intertidal zone has the potential to directly impact archaeological material which may survive, buried within intertidal deposits. However, with the implementation of long HDD the drill will pass beneath the intertidal zone, within the underlying glacial till which, being of glacial origin, is not considered to be of archaeological potential. This also reduces any potential for drilling fluid break out to impact archaeological deposits or features within the intertidal zone and any potential negative effect from drilling fluid upon site preservation would be negligible as a worst case.

There is, however, the potential for impact at the point of HDD exit within the nearshore area.

With respect to the potential for submerged prehistoric archaeology and palaeoenvironmental data within these nearshore deposits, a programme of geoarchaeological assessment is being progressed by Wessex Archaeology as a means to mitigate potential impacts to prehistoric deposits of archaeological potential. This programme has been agreed in consultation with Historic England and the results of the assessment, which includes the palaeoenvironmental analysis of samples from cores obtained during geotechnical survey campaigns undertaken in 2015, 2016 and 2017/2018, are contributing to the development of a Quaternary sedimentary deposit model for the TK Array and TK Electrical System areas (Wessex Archaeology, 2016b, 2017a, 2017b and 2018).

With respect to the potential for maritime and aviation archaeology to be present at the location of

the HDD exit points, a review of the updated gazetteer and baseline shows that there is a single Archaeological Exclusion Zone (AEZ) within the nearshore area. This corresponds to anomaly ID 7709, a small but distinct wreck site which appears to be upright and intact but mostly buried and associated with a relatively small magnetic anomaly, potentially a small, wooden local vessel (Royal HaskoningDHV, 2018). This AEZ (comprising a buffer of 50m around the wreck boundary as seen in the geophysical data) is located to the north of the cable route and, as all works are prohibited within the boundary of the AEZ, no activities relating to HDD, nor to the installation of the cable seaward of the exit pit (such as vessel anchoring, for example), would be undertaken within this boundary.

There are two further geophysical anomalies of potential archaeological interest located within the nearshore area. Anomaly 7708 was interpreted by Headland (2014) as possible fishing gear and was re-interpreted by Wessex Archaeology (2016a) as a dark reflector which could be natural in origin or possibly non-ferrous debris. Anomaly 7710 has been interpreted as a possible natural feature or partially buried ferrous debris. Both anomalies will be avoided during HDD. Furthermore, high resolution geophysical data from this area, acquired during the planned pre-construction survey, will be archaeologically assessed to provide any further indication of the presence of potential archaeological remains. In the event that further anomalies are identified, these would also be avoided in the final design of the HDD in accordance with the embedded mitigation presented in the WSI. If these could not be avoided then further investigation and mitigation would be agreed in consultation with Historic England.

These findings are in line with those assessed within the TK Electrical System ES for cable installation within this area and as such the revised HDD methodology is not considered to result in an effect which exceeds that already predicted, with similar works for cable installation considered in the TK Electrical System ES and determined to be not significant.

Therefore, the revised HDD methodology is not considered likely to result in a significant effect on marine archaeology receptors. There is no change to the original ES conclusion of a not significant impact on marine archaeology as a result of the revised HDD methodology.

4.4.2.2   Increased Suspended Sediment Concentrations

As considered in the TK Electrical System ES (Document Ref: 6.2.2.11) an increase of SSC may result in a slight beneficial effect. It is possible that changes to SSC could have a beneficial effect on archaeological receptors as the when the sediments settle out of suspension it could provide additional cover and thus further protection to those archaeological receptors.

4.5   Summary

The following potential environmental effects were screened out of further investigation as they are considered to be fully considered within the TK Electrical System ES:

- Vessel disturbance/ collision risk for marine mammals;
- Vessel disturbance on marine ornithology; and
- Direct disturbance of benthos and NERC habitats (see Section 3.5).

Marine water quality, benthic ecology and marine archaeology were considered in more detail. No likely changes to the significance levels predicted within the TK Electrical System ES have been identified within this assessment for the disturbance of seabed or release of drilling mud (Bentonite) below MWLS.

The findings are in line with those assessed within the original TK Electrical System ES for cable installation within this area and were found to be not significant. The proposed works are temporary and short term and any resulting effects will be minimal and localised. As such the revised HDD methodology is not considered to result in effects exceeding those previously predicted. It is therefore considered that the revised HDD methodology sits within the existing dML and should not be subject to a variation or additional Marine Licence application.

5   POTENTIAL CUMULATIVE EFFECTS

The assessment of cumulative effects presented in the ES for each of the technical topics was presented in the TK Electrical System ES (Volume 1, Chapter 3, Reference: 6.2.1.3). The assessments considered both current and proposed projects, plans and activities at the time of writing. This provided for consideration of effects drawn from both the existing baseline and the future predicted baseline for the actual construction of the project up to 2023. The assessment included not only other existing, proposed or planned offshore wind farms but also other types of development or activities taking place in the wider area. This information has been utilised in order to provide consideration of any potential cumulative effects from the release of drilling mud (Bentonite) below MLWS.

In the period since the TK Electrical System ES was published, Hornsea Project TWO Offshore Wind Farm has received Contracts for Difference (CfD). Therefore, this project would now be considered as Tier 1 and relevant to the cumulative assessment. This project is approximately 65km from the proposed HDD works, which are limited to activities within the export cable corridor, and as a result no significant cumulative effects are considered likely to arise. It is considered that cumulative effects associated with the proposed works are sufficiently limited in spatial and temporal extent that they will not combine with those of the wider development to result in any cumulative effect greater than that already predicted within the ES.

The characterisation of effects as presented within Section 4 of this report has identified that all effects will be highly localised and short term in nature and will not result in significant adverse impacts. This is consistent with the findings of the cumulative effects assessed in the TK Electrical System ES for the same receptors. When these effects are then considered in the context of the information on the current and proposed projects, plans and activities detailed in the ES, the potential for release of drilling mud contributing in a cumulative manner is also considered to be extremely unlikely and of minimal impact.

6   CONCLUSIONS

This Environmental Information Report has been prepared in advance of proposed HDD works associated with TKOWF. It is intended to provide the regulatory authorities (and their statutory advisers, where relevant) with the necessary supporting information to justify that an additional Marine Licence or variation to the existing deemed Marine Licence is not required.

The findings of this assessment are that the revised HDD methodology sits within the Rochdale envelope assessed within the TK Electrical System ES.

The findings are that all potential effects are in line with those predicted within the ES and conclude that:

- There is no risk of a likely significant effect on European sites or Habitats of Principal Importance;
- There is no risk of non-temporary significant effect on the relevant water body;
- There is no risk of harm or degradation to the relevant bathing water quality;
- There is no increased risk of degradation of water quality;
- There is no increased risk to benthic receptors;
- There is no increased risk to marine archaeology receptors; and
- There is reduced risk of disruption to the public compared to the original methodology which included excavation pits located on the beach.

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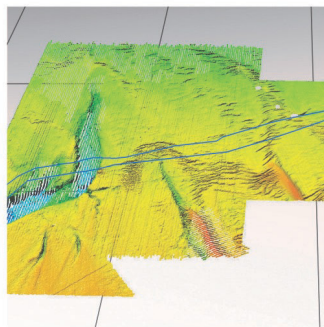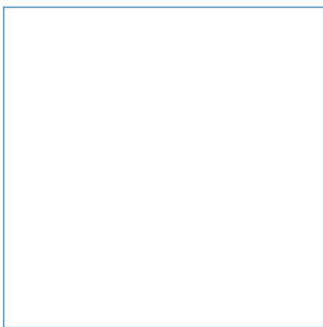## APPENDIX A: INVESTIGATION INTO THE FATE OF SEDIMENT DISTURBED BY MASS FLOW EXCAVATION DREDGING
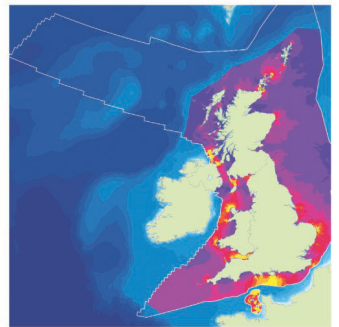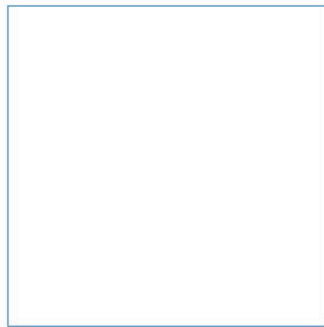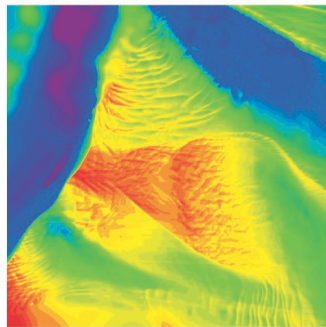
GoBe Consultants Ltd

Triton Knoll Electrical System Landfall
Investigation into the fate of drill fluid and drill arisings

June 2018

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1   Introduction

Innogy Renewables UK Ltd have identified Horizontal Directional Drilling (HDD) as the preferred option to connect the Triton Knoll wind farm array to the onshore grid at a landfall near Anderby Creek, Lincolnshire. The drill punch-out location will be around the -5 mLAT mark, with a drill length of approximately 650 to 1,250 m. The release of drilling fluid (a suspension of natural bentonite clay in water, also likely containing some drill cuttings) into the coastal waters was not considered within the design envelope for the Triton Knoll Electrical System (TK Electrical System) Environmental Impact Assessment (EIA) studies. Therefore this report has been produced

to consider the fate of the bentonite clay and any drill cuttings within any drilling fluid that might be released as part of the engineering process for the HDD works.

This assessment also provides specific information to support a separate assessment of bathing water quality at 'Moggs Eye' and 'Anderby' (approximately 400 m north and 850 m south of the HDD location, respectively).

This investigation therefore focuses upon the likely rate of dispersion of any drilling fluid plume and so the maximum suspended sediment (bentonite) concentrations (SSC), and the thickness of any measureable accumulations of bentonite and drill cuttings (if any) that might be expected in the vicinity of the release location.

2   Baseline Understanding

Baseline characteristics and coastal processes understanding of the marine physical environment at the landfall were previously investigated and described in the Triton Knoll Wind Farm Environmental Assessment Report (ABPmer, 2014). The description was based on analysis of both project and non-project specific data (hydrodynamic, geophysical and geotechnical) as well as numerical modelling undertaken by ABPmer to inform the TK Electrical System EIA. Key relevant characteristics of the coastal processes environment at the landfall (also applicable to the two nearby bathing water areas) are briefly summarised below from ABPmer, 2014:

- The landfall is located in a macro tidal setting, with a mean spring range of approximately 5.2 m. Key tidal water levels are provided in Table 1;

- In the vicinity of the landfall, peak mean spring tidal current speeds are approximately 0.6 m/s and peak mean neap tidal current speeds are approximately 0.3 m/s. Tidal current speeds will be less than the peak value for most of the tidal cycle (including periods of slack water around the time of flow reversal on every tide). Tidal current speeds may be relatively reduced in shallower water (less than a few metres). Tidal current directions are aligned approximately parallel to the coast, with ebb currents to the north and flood currents to the south;

- In nearshore areas, additional alongshore currents caused by waves may be locally superimposed upon tidal currents. The direction of the wave induced current will depend on the direction of the waves relative to the shoreline. The local speed and distribution (offshore extent) of the wave induced current will also depend on the distribution of wave heights and periods in the seastate and the water level at the time of the event. The net effect of wave induced and tidal currents may be an increase or a decrease in overall current speed depending on their direction relative to each other;

- Peak current speeds of 0.3 and 0.6 m/s correspond to tidal excursion distances (the distance over which water is moved by tidal currents during one flood or ebb period) of approximately 4.25 and 8.50 km (representative of mean neap and spring conditions, respectively);

- Long term residual tidal currents and the long term net effect of waves on alongshore sediment transport processes are directed to the south;

- The landfall is located in a naturally relatively turbid environment: during winter months, surface suspended particulate matter (SPM) concentrations (similar to SSC but also including organic contributions) may be in the range ~50 to 70 mg/l, reducing to ~5 to 15 mg/l during summer months (Dolphin *et al.,* 2011; Cefas, 2016);

- Waves in shallow water may also locally naturally stir and resuspend seabed sediments, causing nearbed SSC to be an order of magnitude (or more) greater than that encountered at the water surface (as described above). This is particularly the case during storm events;

- The coastal frontage at Anderby Creek (where the cable makes landfall) is characterised as a sandy beach backed by vegetated sand dunes. In shallow sub-tidal areas adjacent to the beach, the seabed comprises silty gravelly sands. The thickness of the surficial sediment unit is spatially variable but may be no greater than *circa* 1 m above the underlying Bolders Bank clays; and

- Beach levels in such open coastal environments natural vary seasonally due to normal beach processes: during the winter, steeper waves and more frequent storm events tend to transport sand offshore into nearshore bar features, creating a steeper beach profile; and, during the summer, less steep waves tend to return sand to the beach, creating a shallower beach profile.

Table 1.   Tidal water levels

Key Tidal Level	Abbreviation	Water Level (mCD)
Highest Astronomical Tide	HAT	7.10 m
Mean High Water Spring	MHWS	6.40 m
Mean High Water Neap	MHWN	5.10 m
Mean Low Water Neap	MLWN	2.50 m
Mean Low Water Spring	MLWS	1.2 m
Lowest Astronomical Tide	LAT	0.2 m

Source: Admiralty, 2018

3   Assessment

3.1   Assessment scenario details and assumptions

The physical characteristics of the HDD for the assessment have been provided by the HDD contractor via GoBe in the form of a project specific method statement (VBNK, 2018) and other clarifications by email. Relevant details are summarised as follows:

- There will be two HDD holes drilled, one for each export cable;

- The minimum time between (bentonite releases from) each of the drills will be 4 days;

- There will be two punch outs, one for each hole drilled;

- There will be no break outs (release of bentonite between the planned entry and exit points due to thin or porous soils over the drill);

- The starting or entry point for the HDD will be located onshore, within a controlled area that would prevent release of bentonite from this location into the intertidal area;

- Each HDD will be between 0.65 and 1.25 km in length. The punch out locations will be between KPs 0.65 and 1.25 (between 650 to 1,250 m offshore of the HDD entry points) where the seabed is approximately -5.0 mLAT;

- The hole will be drilled in stages. The first stage will create a narrower pilot hole using a drilling tool. The pilot hole will be subsequently enlarged by reaming (progressively cutting and/or flushing material to achieve the final diameter). The final ream diameter will be up to 1,300 mm, to allow for a high density polyethylene (HDPE) pipe of 900 mm diameter;

- The offshore exit pits into which the HDD will punch out will be at least approximately 5 m wide x 75 m long (at the base). The pit will be at least approximately 2.5 m deep at the nearshore side and 1.8 m deep at the offshore side. Pit dimensions may be up to 10 to 20 % larger than these minimum values and side slopes may also be required for stability, depending on local access requirements and ground conditions;

- Drilling mud/fluid, consisting of a mixture of water and bentonite clay will be pumped down the drill string to break up and flush the material in front of and around the jet bit and flow back via the drilled hole to the mud pit at the entry site.

The method statement from the drilling contractors (VBNK, 2018) provides the following information about the purpose and nature of the drilling fluid:

- Drilling fluid is a composite made of bentonite and water with the following functions:

    o To remove cuttings from in front of the drill bit;
    o Power the mud motor;
    o To transport cuttings from the drill face through the annular space towards the surface;
    o Lubricate the drill string during drilling phases and HDPE strings during pull back;
    o Cooling the reamers (cutting tools);
    o Hole stabilization; and
    o Creation of a filter cake against the wall of the hole to minimize the risk of loss of drilling fluid or influx of groundwater penetration into the borehole.

- The drilling fluid consists of a low concentration bentonite – water mixture. Depending on the formation to be drilled through, the concentration of is between 13 litres (30 kg) and 35 litres (80 kg) of dry bentonite clay per m^3 of water;

- Up to 200 tonnes of bentonite will be suspended in 3,000 to 4,000 m^3 of water to create the drilling fluid;

- The use of bentonite has a number of benefits:

    o It is a natural material, so no chemical;
    o It is recyclable;
    o It is on the PLONOR[1] list, so discharge is not a danger to the environment;

- Owing to the large diameter pipe and long length, the total volume of fluid is considerable, but, owing to the low concentration, the total amount of bentonite is limited.

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[1]   Substances that 'Pose Little or No. Risk to the Environment' (PLONOR).

Based upon the above information, the following scenario assumptions are made about the potential total quantities and rate of bentonite and drill cuttings release as drilling fluid and form the basis of the assessment.

- Three scenarios for the total mass of bentonite released per bore are considered (in conjunction with the smallest expected volume of water to yield the greatest concentration):
  - Base case – 30 tonnes bentonite in 450 m^3 of water;
  - Contingency 1 – 100 tonnes bentonite in 1,500 m^3 of water;
  - Contingency 2 (worst case) – 200 tonnes bentonite in 3,000 m^3 of water.

- Up to 10 tonnes of bentonite could be forcefully and suddenly released under pressure (e.g. at punch out);

- Any further release of bentonite would be more passive (not under pressure), at a gradual representative rate of 20 tonnes per 24 hours;

- Assume up to 10% of the drilling fluid volume will be drill cuttings, which will be natural materials (sands or clays) and may be relatively fine or coarse in nature;

- Assume that up to 100% of the released bentonite is pooled within the excavated exit pit, or, up to 100% of the released bentonite is dispersed more widely in suspension, or, any proportional combination of these two end members;

- For the purposes of dispersion calculations, a representative ambient current speed of 0.3 m/s is used (peak flow during mean neap tides and a typical mid tide current speed during mean spring tides).

- The distance of one tidal excursion (4.25 to 8.50 km for mean neap and mean spring conditions, respectively) reasonably describes the maximum distance that a plume might be advected on a single tide.

3.2   Method

This assessment is undertaken as a semi-quantitative desktop study, using spreadsheet calculations to realistically estimate the properties, extent, duration and thickness of any accumulations resulting from the potential bentonite release scenarios.

This approach is robust as the total mass of bentonite clay being used and potentially released are known and finite. As such, from any initial condition, a greater extent or duration of effect will implicitly correspond to a proportionally smaller concentration or thickness of deposition, and vice versa.

An assessment of the (more likely) normally expected (base case), an intermediate (contingency 1) and the (less likely) worst case scenario (contingency 2) release volumes are provided for context.

In addition to these scenarios, a range of 'end member scenarios' are considered in relation to assessments of deposition thickness where the actual pattern of deposition cannot be predicted with certainty. For example, the case of all bentonite accumulating in the exit pit, and, the case of all bentonite being dispersed widely are considered. Whereas, in practice, the actual outcome is more likely to be some proportional mixture of these conditions.

3.3   Results

3.3.1   Drilling fluid properties

The properties of the drilling fluid including the total mass and volume of bentonite and water used in the drilling fluid are described in Table 2. The bulk density of the drilling fluid and the bulk density and maximum volume of bentonite should it settle and become consolidated are also provided.

It is noted that the proportion of bentonite to fresh water (up to 200 tonnes of bentonite in 3,000 to 4,000 m³ of water) in the drilling fluid corresponds to a concentration range of 64,706 to 48,889 mg/l and a bulk density range of 1,035.3 to 1,026.7 kg/m³, respectively. The drilling fluid will therefore have a density similar to that of seawater (approximately 1,028 kg/m³) and will therefore likely behave and disperse within the water column as a water-like fluid, i.e. the drilling fluid is less likely to flow or behave as a separate layer due to differences in density.

Table 2.   Drilling fluid properties

Quantity	Value	Unit	Notes
Total mass of bentonite	200	tonnes	Proposed method (VBNK, 2018)
Total mass of bentonite	200,000	kg	200 tonnes x 1,000 kg/Tonne
Bentonite mineral solid density	2200	kg/m³	www.bentonite.it (in range 2,200 to 2,800 kg/m³)
Equivalent total volume of solid bentonite	90.9	m³ solid bentonite	200,000 kg / 2,200 kg/m³
Total volume water	3,000	m³ water	Proposed method (VBNK, 2018). Can be in the range 3,000–4,000 m³. Smaller value is conservatively used to yield the largest SSC for the drill fluid.
Total mass of (fresh) water	3,000,000	kg	3,000 m³ x 1,000 kg/m³
Total volume of bentonite and water	3,090.9	m³	90.9 m³ + 3,000 m³
Bulk density of mixed drilling fluid	1,035.3	kg/m³	(200,000 kg + 3,000,000 kg) / 3,090.9 m³
Suspended sediment concentration of drilling fluid (bentonite in water)	64,706	mg/l	(200,000 kg / 3,090.9 m³) * 1,000 (1 kg/m³ = 1,000 mg/l)
Consolidated bulk density of bentonite if settles	300	kg/m³	(Whitehouse *et al* 2000). "Fluid mud dewaters… to form a weak soil with a density of 100 to 300 kg/m³ which does not flow easily".
Potential reconsolidated volume of all bentonite	666.7	m³	200,000 kg / 300 kg/m³ (if deposited locally and dewatered to form a weak soil).

3.3.2   Mass and volume of bentonite release scenarios

The mass and volume of bentonite that might be released is described in Table 3. It is noted that the normally expected mass of bentonite release (base case, 30 tonnes) is relatively small in comparison to the more unlikely worst case (contingency 2, 200 tonnes). The mass of bentonite and the corresponding volume of drilling fluid that might be suddenly released under pressure at punch out is the same in all cases (10 tonnes) and is a relatively small proportion (5%) of the total volume of drilling fluid used.

Table 3.   **Mass and volume of bentonite release scenarios**

Quantity	Value	Unit	Notes
Total mass of bentonite released (base case)	30	tonnes	Proposed method (VBNK, 2018) Best case
Total mass of bentonite released (contingency 1)	100	tonnes	Proposed method (VBNK, 2018) Intermediate case
Total mass of bentonite released (contingency 2)	200	tonnes	Proposed method (VBNK, 2018) Worst case
Mass of bentonite released under pressure at punch out	10	tonnes	Proposed method (VBNK, 2018) All cases
Mass of bentonite released under pressure at punch out	10,000	kg	10 tonnes x 1,000 kg/tonne
Volume of drilling fluid (bentonite in water) released under pressure at punch out	154.5	m^3	3,090 m^3 x (10 tonnes / 200 tonnes)
Percentage of all drilling fluid released under pressure	5	%	(10 tonnes / 200 tonnes) x 100
Maximum percentage of all drilling fluid released passively (Base Case)	10	%	((30 tonnes - 10 tonnes) / 200 tonnes) x 100
Maximum percentage of all drilling fluid released passively (Contingency 1)	45	%	((100 tonnes - 10 tonnes) / 200 tonnes) x 100
Maximum percentage of all drilling fluid released passively (Contingency 2)	95	%	((200 tonnes - 10 tonnes) / 200 tonnes) x 100

3.3.3   HDD exit pit dimensions

The HDD exit pit dimensions and the corresponding area and volume are described in Table 4. A range of pit dimensions are realistically possible, depending on the site specific practical access requirements and local ground conditions. In later assessment calculations, the representative exit pit floor area is used to estimate the thickness of consolidated deposits and the representative volume of the pit is compared to the maximum consolidated volume of bentonite and drill cuttings. In practice, the slide slopes of the pit may need to be angled for stability, which may further widen the top dimensions of the pit, and the overall pit volume. This would result in correspondingly smaller estimates of average consolidated sediment thickness, which are more likely to be contained within the exit pit. The representative pit dimensions (excluding slopes) therefore provide conservatively realistic values to inform the assessment.

Table 4.   Approximate HDD exit pit dimensions

Quantity	Value	Unit	Notes
Minimum exit pit width	5	m	Proposed method (VBNK, 2018)
Minimum exit pit length	75	m	Proposed method (VBNK, 2018)
Minimum exit pit depth (landward)	2.5	m	Proposed method (VBNK, 2018)
Minimum exit pit depth (seaward)	1.8	m	Proposed method (VBNK, 2018)
Minimum exit pit area	375	m^2	5 m x 75 m
Minimum exit pit volume	806	m^3	5 m x 75 m * ((1.8 m + 2.5 m)/2)
Representative exit pit area (dimensions + 10%)	454	m^2	5.5 m x 82.5 m
Representative exit pit volume (dimensions + 10%)	1,073	m^3	5.5 m x 82.5 m * ((1.98 m + 2.75 m)/2)
Maximum exit pit area (dimensions + 20%)	540	m^2	6.0 m x 90.0 m
Maximum exit pit volume (dimensions + 20%)	1,393	m^3	6 m x 90 m * ((2.16 m + 3.0 m)/2

3.3.4 Bentonite SSC resulting from initial drilling fluid release under pressure

A spreadsheet based plume dispersion model is provided in Table 5 to describe the reduction in bentonite SSC within the plume resulting from the sudden release of 10 tonnes of bentonite (154.5 m^3 of drilling fluid with an initial SSC of 64,706 mg/l). The initial dimensions of the plume (5.4 x 5.4 x 5.4 m), contain the total volume of the released drilling fluid, and assume that the plume initially develops without any mixing, spreading equally in all directions from the punch out location. Other dispersion scenarios shown in the table represent the gradual dispersion of the initial plume, which increases the total volume of water within the plume resulting in a corresponding reduction in average SSC. These are realistic outcomes as it was shown in Table 2 that the drilling fluid will behave (mix and disperse) in a manner similarly to seawater.

Table 5.   SSC in plume resulting from drilling fluid released under pressure

Scenario: Punch Out Sudden Release Under Pressure	Plume Width (m)	Plume Height (m)	Plume Length (m)	Resulting SSC (mg/l)
Source concentration (localised plume from 100% of drill fluid volume released under pressure). At time of release.	5.4	5.4	5.4	64,706
Vertical diffusion to 10 m (approximately full water column), 20 m lateral spread in footprint dimensions). Approx. 20 minutes following release.	20	10	20	2,500
Vertical diffusion to 10 m (approximately full water column), 50 m lateral spread in footprint dimensions). Approx. 3 hours following release.	50	10	50	400
Vertical diffusion to 10 m (approximately full water column) 150 m lateral spread in footprint dimensions). Approx. 24 hours following release.	150	10	150	44

The initial plume will have a very high SSC of bentonite but will have a correspondingly small footprint. The plume will subsequently be advected in the general direction and speed of the ambient currents at the time of the release and will be gradually dispersed both horizontally and vertically by the natural processes of diffusion. The mass of bentonite in the plume is finite (10 tonnes) and so SSC within the plume will become diluted and reduced in proportion to the increase in the overall volume of the plume. The spreadsheet model shows that concentrations of bentonite will be reduced to naturally occurring background levels when the plume has a footprint in the order of 150 m across.

The time required to achieve such dispersion cannot be calculated with certainty but is estimated to be in the order of hours based on normal tidally induced turbulence. If waves are active at the time of the release, wave induced turbulence at the seabed and wave breaking nearshore would result in much higher rates of dispersion.

The mass of bentonite is assumed to remain unchanged in this model, which is realistic as the bentonite is a fine grained clay suspension that is expected take at least hours, if not days or longer to settle out of suspension under suitable conditions. If any bentonite does settle out of suspension more rapidly, then SSC in the plume would be reduced accordingly. If the released drilling fluid does behave as a more dense fluid for any reason, some or all may accumulate in the exit pit (possibly becoming consolidated over days to weeks, see Table 8 and associated text), and/or some or all may move over the adjacent seabed downslope under gravity, i.e. in an offshore direction and away from the nearshore areas.

It is noted that the HDD exit point will be approximately 500 m or more offshore of the beach. The currents advecting the plume are aligned parallel to the coast and so it is reasonable to assume that the plume will largely remain a similar distance offshore and therefore may not overlap the nearby (nearshore) bathing water areas at all. If the plume experiences sufficient lateral diffusion to reach the adjacent shoreline, then Table 5 demonstrates that the corresponding SSC would be very low (within the range of naturally occurring values).

The effects of the plume will also be of very short duration and temporary at any given location. Being advected at the representative current speed (0.3 m/s), the initial highest concentration plume (5.4 m across) would affect any given location for less than approximately 30 seconds. A larger footprint plume with measurably elevated SSC (e.g. 50 m across, 400 mg/l) would take only approximately 3 minutes to pass. The plume as a whole would be advected past the two nearby bathing water areas (400 and 850 m away) within approximately 20 to 50 minutes of release, respectively. At times of stronger flow (e.g. up to 0.6 m/s peak current speed on a mean spring tide) these timescales could be reduced proportionally.

3.3.5   Bentonite SSC resulting from further passive drilling fluid release

Following the initial release of drilling fluid under pressure (as described in Section 3.3.4), a further volume of drilling fluid may be released passively, i.e. at a slower rate over a longer time period associated with ongoing operations following punch out. The volumes of drilling fluid passively released in the various release scenarios is provided in Table 3.

The rate of drilling fluid release during this more passive period is described in Table 6. The estimated rate of 20 tonnes/24 hrs corresponds to a relatively small average rate of release (approximately 4 litres of drilling fluid per second. It is noted that the nature of the released drilling fluid (bentonite SSC, density, etc.) is the same as that of the 'under pressure release' scenario and as previously described in 3.3.1. At this relatively low rate, the remaining bentonite release in each scenario will occur gradually over a matter of 1 to 10 days. If the release is actually more episodic (i.e. a number of intermittent higher rate releases), then that effect of each event will be some intermediate condition between that described in Section 3.3.4 and that described below.

Table 6.   Rate of passive bentonite release

Quantity	Value	Unit	Notes
Passive rate of bentonite release	20	tonnes/24 hrs	Proposed method (VBNK, 2018)
Passive rate of bentonite release	0.00023	tonnes/s	20 tonnes/24 hrs / (24 x 60 x 60 s/24 hrs)
Passive rate of bentonite release	0.23	kg/s	0.000231481 tonnes/s x 1,000 kg/tonne
Passive rate of drill fluid (water+bentonite) release	0.00358	m^3/s	0.23 kg/s x (3,090.9 m^3 / 200,000 kg)
Suspended sediment concentration of drilling fluid (bentonite in water)	64,706	mg/l	(200,000 kg / 3,090.9 m^3) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Duration of passive plume release (base case)	24 (1)	hrs (days)	(30 tonnes – 10 tonnes) / 20 tonnes/24 hrs
Duration of passive plume release (contingency 1)	108 (4.5)	hrs (days)	(100 tonnes – 10 tonnes) / 20 tonnes/24 hrs
Duration of passive plume release (contingency 2)	228 (9.5)	hrs (days)	(200 tonnes – 10 tonnes) / 20 tonnes/24 hrs

During the time that drilling fluid is being released at the rate described above, a small plume of drilling fluid will be continuously locally created and advected away by the ambient currents. A spreadsheet based plume dispersion model (similar to that described in Section 3.3.4) is provided in Table 7 to describe the dimensions of the plume and the reduction in bentonite SSC within the plume due to general dispersion. The model considers one second worth of discharge which, at the representative flow rate of 0.3 m/s, corresponds to a discrete section of the plume that is 0.3 m in length. The initial height and width of the plume (0.1 m) are calculated based on the volume of drilling fluid released in one second (0.00358 m^3) and the plume section length. Other dispersion scenarios shown in the table represent the gradual vertical and horizontal dispersion of the initial plume, which increases the total volume of water within the plume resulting in a corresponding reduction in average SSC. These are realistic outcomes as it was shown in Table 2 that the drilling fluid will behave (mix and disperse) in a manner similarly to seawater.

Table 7.   SSC in plume resulting from remaining drilling fluid released passively

Scenario: Punch Out Sudden Release Under Pressure	Plume Width (m)	Plume Height (m)	Plume Length (m)	Resulting SSC (mg/l)
Source concentration (gradually released continuous plume, per second of release)	0.1	0.1	0.3	64,706
Vertical and horizontal diffusion to 1 m wide and 1 m high.	1	1	0.3	772
Vertical and horizontal diffusion to 5 m wide and 5 m high.	5	5	0.3	31
Vertical and horizontal diffusion to 10 m wide and 10 m high.	10	10	0.3	8

The spreadsheet model shows that concentrations of bentonite will be reduced to naturally occurring background levels when the plume has a footprint in the order of 5 to 10 m across. The footprint of the measurable plume is clearly small in both absolute and relative terms.

As discussed in Section 3.3.4 for the larger initial release plume, any measurable effect of the passively released plume is likely to remain offshore and so is unlikely to overlap with the nearby nearshore bathing water areas.

Although the plume may be created continuously over of a matter of days, the path of the plume will naturally vary due to turbulence and flow reversal during flood and ebb tidal periods. It is likely that any location more than a few tens of metres from the point of release would only be affected intermittently by the plume.

3.3.6   Maximum thickness of bentonite and drill cuttings deposits

It is considered most likely that most or all of the bentonite released will be held in suspension for days to weeks or longer before settling. In this time, the individual grains will become dispersed widely over very large areas and so will not result in any measurable thickness of bentonite accumulation or change in sediment type or texture.

In the unlikely event that all of the released bentonite material collects within the depression of the HDD exit pit and is loosely consolidated, the maximum thickness of the resulting deposits is described in Table 8 for the initial release under pressure and for the remaining passive release under each release scenario.

The potential thickness of consolidated bentonite from the initial release of 10 tonnes under pressure (same for all cases) is small in both absolute and relative terms and in any case is considered highly unlikely to occur (see Table 5 and associated text).

The total consolidated thickness of bentonite resulting from the base case passive release is small in both absolute and relative terms. In the worst case (contingency 2), the thickness of the deposit is still smaller than the minimum depth of the pit (1.8 to 2.16 m at the offshore end), which suggests that the majority of released bentonite could be contained within the HDD exit pit (in this unlikely event).

Table 8.   **Maximum thickness of consolidated bentonite deposits if accumulated in the exit pit**

Quantity	Value	Unit	Notes
Average thickness of consolidated bentonite in exit pit (all bentonite released under pressure, all cases)	0.07	m	(666.7 m³ x 5 %) / 454 m²
Average thickness of consolidated bentonite in exit pit (all passively released bentonite, base case)	0.15	m	(666.7 m³ x 10 %) / 454 m²
Average thickness of consolidated bentonite in exit pit (all passively released bentonite, contingency 1)	0.66	m	(666.7 m³ x 45 %) / 454 m²
Average thickness of consolidated bentonite in exit pit (all passively released bentonite, contingency 2)	1.40	m	(666.7 m³ x 95 %) / 454 m²

It is relatively more likely that the majority of drill cuttings contained within the released drilling fluid will be sand sized or coarser and will be deposited rapidly to the seabed within or around the HDD exit pit. Various calculations are provided in Table 9. The maximum total volume of drill cuttings created (equivalent to the volume of the final drilled hole, up to 1,659 m³) is relatively large, however, only a small proportion of all drill cuttings will be present in the drilling fluid at any one time. The maximum proportion of drill cuttings that might be released is estimated by assuming that a volume of drilling fluid equal to the total volume of the drilled hole is released and that 10 % of that volume of drilling fluid is drill cuttings.

Although the final distribution of drill cuttings (and so the shape and dimensions of the resulting deposit) cannot be predicted with certainty, the average depth to which drill cuttings might accumulate in the exit pit (0.37 m) is small in absolute and relative terms.

Table 9. **Maximum volume and thickness of consolidated drill cuttings if accumulated in the exit pit**

Quantity	Value	Unit	Notes
Maximum length of HDD	1,250	m	Proposed method (VBNK, 2018)
Maximum final ream diameter	1.3	m	Proposed method (VBNK, 2018)
Maximum volume of drilling fluid within the HDD hole (and total volume of all drill cuttings)	1,659	m³	$\pi \times (1.3\ m / 2)^2 \times 1,250\ m$
Maximum proportion of drilling fluid volume that is drill cuttings	10	%	Assumption
Maximum volume of drill cuttings potentially released	165.9	m³	1,659 m³ x 10 %
Average thickness of drill cuttings if accumulated in the exit pit	0.37	m	165.9 m³ / 454 m²

4   Conclusions

The results show that the release of bentonite and drill cuttings in the form of drilling fluid from the planned HDD operations will result in a localised and temporary plume of elevated bentonite SSC. Where the plume has measureable SSC that might be of concern to bathing water quality, the duration and footprint of the plume will be small in absolute and relative terms (order of metres over a period of days or order of tens of metres over a period of seconds to minutes).

In any case, the HDD exit point is located approximately 500 m or further offshore of the beach. Any plume will be advected in the direction of the ambient tidal currents, which are aligned parallel to the coast and therefore will remain a similar distance offshore. The largest anticipated plume would be dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles.

The bentonite in the drilling fluid is expected to remain in suspension for at least hours or days and will be widely dispersed before settling. Therefore, bentonite is not expected to accumulate anywhere

in measurable thicknesses. If, however, bentonite and/or drill cuttings did accumulate in or around the HDD exit pit, the volume of the pit is theoretically sufficient to contain the full volume of that material.

The bentonite in the drilling fluid is expected to behave (advect, mix and disperse) in a similar manner to seawater. If the drilling fluid behaves as a more dense fluid, it will either accumulate in the HDD exit pit or move over the adjacent seabed downslope under gravity, i.e. in an offshore direction and away from nearshore areas.

5   References

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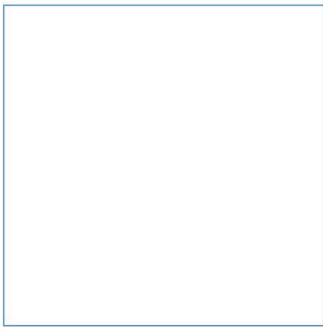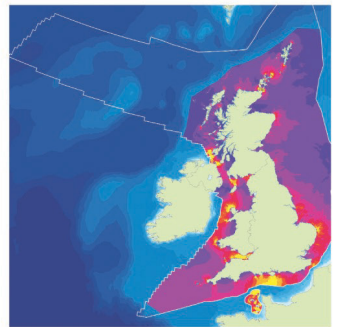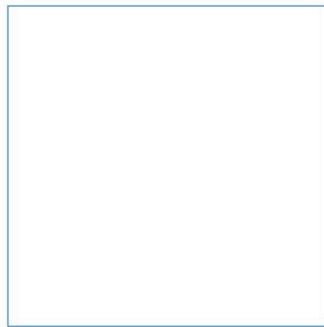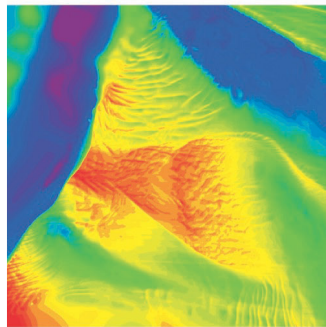# APPENDIX B: INVESTIGATION INTO THE FATE OF DRILL FLUID AND DRILL ARISINGS

GoBe Consultants Ltd

Triton Knoll Electrical System Landfall
Investigation into the fate of sediment disturbed by mass flow excavation dredging
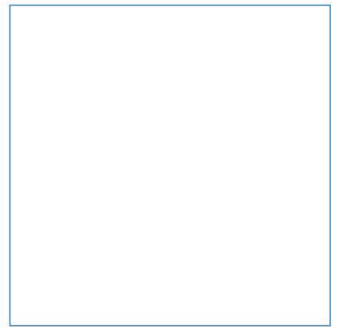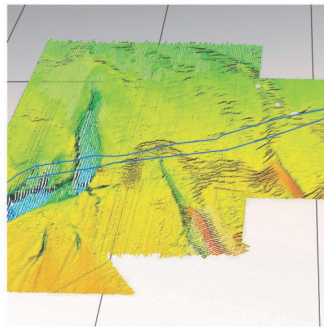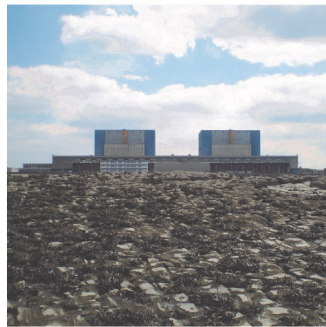
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Triton Knoll Electrical System Landfall
Investigation into the fate of sediment disturbed by mass flow excavation dredging

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Tables

1   Introduction

Triton Knoll Offshore Wind Farm Limited (TKOWFL) have identified Horizontal Directional Drilling (HDD) as the preferred option to connect the Triton Knoll Offshore Wind Farm Array to the onshore grid at a landfall near Anderby Creek, Lincolnshire. The drill punch-out locations for the two cables will be around the -5 mLAT mark, with a drill length of approximately 650 to 1,250 m. Two HDD exit pits will be excavated at the location of the punch out in the subtidal zone and cable ducts installed that can be subsequently buried upon completion of the work.

The HDD works are scheduled for Q1-Q2 2019. The works involve the drilling of two bores from the onshore entry point to the offshore exit point to allow for the installation of High Density Polyethylene (HDPE) pipes. Later the two installed pipes will provide safe and secure conduits to pull-in the two export cables from offshore to onshore under the beach and sea defence dunes. The cables are due to be installed in Q2 2020. During the time between the initial excavation of the HDD pits and subsequent infill upon completion the HDD excavation pits may infill via natural sedimentation processes, such as bedload transport and will need to be re-excavated.

ABPmer has been commissioned to undertake an assessment for the re-excavation of these pits, between the ducts being sealed and the cables installed.

This assessment also provides specific information to support a separate assessment of bathing water quality at 'Moggs Eye' and 'Anderby' (approximately 400 m north and 850 m south of the HDD location, respectively).

The scenario for assessment is that a mass flow excavator (MFE) may be needed to remove the sediment from the excavation pits, prior to the removal of the rock bags (or similar) covering the ducts. The MFE will be similar to those used on other offshore wind farm projects. More details on the related representative design specification and other assumptions are given in Section 3.1.

This investigation therefore focuses upon the likely rate of dispersion of any disturbed sediment and so the maximum suspended sediment concentrations (SSC), and the thickness of any measureable accumulations of sediment (if any) that might be expected in the vicinity of the release location.

2   Baseline Understanding

Baseline characteristics and coastal processes understanding of the marine physical environment at the landfall were previously investigated and described in the Triton Knoll Wind Farm Environmental Assessment Report (ABPmer, 2014). The description was based on analysis of both project and non-project specific data (hydrodynamic, geophysical and geotechnical) as well as numerical modelling undertaken by ABPmer to inform the TK Electrical System EIA. Key relevant characteristics of the coastal processes environment at the landfall (also applicable to the two nearby bathing water areas) are briefly summarised below from ABPmer, 2014:

- The landfall is located in a macro tidal setting, with a mean spring range of approximately 5.2 m. Key tidal water levels are provided in Table 1 (similar to but updated from the original report);

- In the vicinity of the landfall, peak mean spring tidal current speeds are approximately 0.6 m/s and peak mean neap tidal current speeds are approximately 0.3 m/s. Tidal current speeds will be less than the peak value for most of the tidal cycle (including periods of slack water around the time of flow reversal on every tide). Tidal current speeds may be relatively reduced in shallower water (less than a few metres). Tidal current directions are aligned approximately parallel to the coast, with ebb currents to the north and flood currents to the south;

- In nearshore areas, additional alongshore currents caused by waves may be locally superimposed upon tidal currents. The direction of the wave induced current will depend on the direction of the waves relative to the shoreline. The local speed and distribution (offshore extent) of the wave induced current will also depend on the distribution of wave heights and periods in the seastate and the water level at the time of the event. The net effect of wave induced and tidal currents may be an increase or a decrease in overall current speed depending on their direction relative to each other;

- Peak current speeds of 0.3 and 0.6 m/s correspond to tidal excursion distances (the distance over which water is moved by tidal currents during one flood or ebb period) of approximately 4.25 and 8.50 km (representative of mean neap and spring conditions, respectively);

- Long term residual tidal currents and the long term net effect of waves on alongshore sediment transport processes are directed to the south;

- The landfall is located in a naturally relatively turbid environment: during winter months, surface suspended particulate matter (SPM) concentrations (similar to SSC but also including organic contributions) may be in the range ~50 to 70 mg/l, reducing to ~5 to 15 mg/l during summer months (Dolphin *et al.,* 2011; Cefas, 2016);

- Waves in shallow water may also locally naturally stir and resuspend seabed sediments, causing nearbed SSC to be an order of magnitude (or more) greater than that encountered at the water surface (as described above). This is particularly the case during storm events;

- The coastal frontage at Anderby Creek (where the cable makes landfall) is characterised as a sandy beach backed by vegetated sand dunes. In shallow sub-tidal areas adjacent to the beach, the seabed comprises silty gravelly sands. The thickness of the surficial sediment unit is spatially variable but may be no greater than *circa* 1 m above the underlying Bolders Bank clays; and

- Beach levels in such open coastal environments natural vary seasonally due to normal beach processes: during the winter, steeper waves and more frequent storm events tend to transport sand offshore into nearshore bar features, creating a steeper beach profile; and, during the summer, less steep waves tend to return sand to the beach, creating a shallower beach profile.

Table 1.   Tidal water levels

Key Tidal Level	Abbreviation	Water Level (mCD)
Highest Astronomical Tide	HAT	7.10
Mean High Water Spring	MHWS	6.40
Mean High Water Neap	MHWN	5.10
Mean Low Water Neap	MLWN	2.50
Mean Low Water Spring	MLWS	1.2
Lowest Astronomical Tide	LAT	0.2

Source: Admiralty, 2018

3 Assessment

3.1 Assessment scenario details and assumptions

The physical characteristics of the HDD exit pits for the assessment have been provided by the HDD contractor via GoBe in the form of a project specific method statement (VBNK, 2018) and other clarifications by email. Relevant details are summarised as follows:

- There will be two HDD holes drilled, one for each export cable;

- There will be two punch outs, one for each hole drilled;

- Each HDD will be between 0.65 and 1.25 km in length. The punch out locations will be between KPs 0.65 and 1.25 (between 650 to 1,250 m offshore of the HDD entry points) where the seabed is approximately -5.0 mLAT; and

- The offshore exit pits into which the HDD will punch out will be at least approximately 5 m wide x 75 m long (at the base). The pit will be at least approximately 2.5 m deep at the nearshore side and 1.8 m deep at the offshore side. Pit dimensions may be up to 10 to 20 % larger than these minimum values and side slopes may also be required for stability, depending on local access requirements and ground conditions.

Example specifications for a representative actual MFE device (a JFSE Twin R2000) from TKOWFL provides the following information about the action of this dredging device type:

- This example MFE generates two controllable columns of seawater which travel vertically down towards the seabed at a velocity of up to 10 m per second;
- The maximum flow rate from each of the fans is 2000 l/s (4000 l/s total);
- A lower flow rate can also be used, depending on the nature of the soils and other requirements; and
- The operating water depth range is 1.5 m to 300 m.

Based upon and further to the above information, the following scenario assumptions are made about the potential total quantities and rate of sediment release and form the basis of the assessment:

- It is assumed that the materials to re-fill the pit will be sands and/or finer material, given the nature of the local sedimentary environment. The accumulated material will likely be generally finer than the material originally excavated from the pits (sands overlying consolidated clays);

- The MFE may be run at less than full (50%) capacity for the some or all of the operation, i.e. a flow rate of 2000 l/s;

- In relation to the sediment type, it is assumed that either:

  o Up to up to 100% of the disturbed sediment volume is sufficiently fine to remain in suspension for extended periods of time (leading to the greatest possible increases in SSC); or,
  o Up to 100% of the disturbed sediment volume is sufficiently coarse to be deposited rapidly to the seabed locally (leading to the greatest possible thicknesses of accumulation); or,
  o Any proportional combination of these two end members.

- The following scenarios for the total volume and mass of sediment released from each HDD exit pit are considered (details are provided in later sections):
  - The maximum possible pit dimensions are used (as described above, +20%);
  - A precautionary assumption of the percentage of the pit volume filled during this period is 75%;
  - Fine sediment accumulating in the pit will be only partially consolidated and so is assumed to have a representative bulk density of 300 kg/m^3 (Whitehouse *et al* 2000); and
  - Coarser sediment (sand) accumulating in the pit is assumed to have a representative packing density (volume of grains / volume of mixture) of 0.6 (Soulsby, 1997). Based on a mineral density for quartz of 2650 kg/m^3, the accumulated sediment is therefore assumed to have a representative bulk density of 1590 kg/m^3.

- For the purposes of dispersion calculations, a representative ambient current speed of 0.3 m/s is used (peak flow during mean neap tides and a typical mid tide current speed during mean spring tides).

- The distance of one tidal excursion (4.25 to 8.50 km for mean neap and mean spring conditions, respectively) reasonably describes the representative distance that a plume might be advected on a single tide.

3.2   Method

This assessment is undertaken as a semi-quantitative desktop study. It uses spreadsheet calculations to realistically estimate the SSC, extent and duration of any sediment plumes and the associated extent and thickness of sediment accumulations resulting from the range of potential sediment disturbance scenarios.

This approach is considered to be appropriate as the maximum total volume and mass of sediment being disturbed is known and finite. As such, from any initial condition, a greater extent or duration of effect will implicitly correspond to a proportionally smaller concentration or thickness of deposition, and vice versa.

In addition to the sediment type scenarios, a range of marginal 'end member' scenarios are considered in relation to assessments of deposition thickness where the actual pattern of deposition cannot be predicted with certainty. For example, the case of all sediment redepositing to the bed within a short distance of the exit pit, and, the case of all sediment being dispersed widely are considered. Whereas, in practice, the actual outcome is more likely to be some proportional mixture of these conditions.

3.3   Results

3.3.1   HDD exit pit dimensions

The HDD exit pit dimensions and the corresponding area and volume are described in Table 2. A range of pit dimensions are realistically possible, depending on the site specific practical access requirements and local ground conditions. In practice, the side slopes of the pit may need to be angled for stability, which may further widen the top dimensions of the pit, and the overall pit volume. This would result in correspondingly larger estimates of accumulated sediment volume requiring excavation. The representative pit dimensions (excluding slopes) are therefore considered to provide conservatively realistic values to inform the assessment.

Table 2. **Approximate HDD exit pit dimensions**

Quantity	Value	Unit	Notes
Minimum exit pit width	5	m	Proposed method (VBNK, 2018)
Minimum exit pit length	75	m	Proposed method (VBNK, 2018)
Minimum exit pit depth (landward)	2.5	m	Proposed method (VBNK, 2018)
Minimum exit pit depth (seaward)	1.8	m	Proposed method (VBNK, 2018)
Minimum exit pit area	375	m^2	5 m x 75 m
Minimum exit pit volume	806	m^3	5 m x 75 m * ((1.8 m + 2.5 m)/2)
Representative exit pit area (dimensions + 10%)	454	m^2	5.5 m x 82.5 m
Representative exit pit volume (dimensions + 10%)	1,073	m^3	5.5 m x 82.5 m * ((1.98 m + 2.75 m)/2)
Maximum exit pit area (dimensions + 20%)	540	m^2	6.0 m x 90.0 m
Maximum exit pit volume (dimensions + 20%)	1,393	m^3	6 m x 90 m * ((2.16 m + 3.0 m)/2)

3.3.2 Sediment properties

The properties of the sediment to be dredged are described in Table 3. Due to differing bulk density, the corresponding total mass of sediment to be dredged is separately calculated for finer and coarser sediment types.

Table 3. **Sediment properties**

Quantity	Value	Unit	Notes
Sediment volumes			
Proportion of pit filled with sediment to excavate	75	%	Conservative assumption provided by TKOWFL
Minimum volume of sediment to excavate	605	m^3	806 m^3 x 75%
Representative volume of sediment to excavate	805	m^3	1,073 m^3 x 75%
Maximum volume of sediment to excavate	1,045	m^3	1,393 m^3 x 75%
Mass of fines			
Consolidated bulk density of fines	300	kg/m^3	(Whitehouse *et al* 2000). "Fluid mud dewaters to form a weak soil with a density of 100 to 300 kg/m^3 which does not flow easily".
Minimum mass of fines	181,406	kg	605 m^3 x 300 kg/m^3
Representative mass of fines	241,452	kg	805 m^3 x 300 kg/m^3
Maximum mass of fines	313,470	kg	1,045 m^3 x 300 kg/m^3
Mass of sand			
Quartz mineral solid density	2,650	kg/m^3	Soulsby (1997)
Packing density of sand grains	0.6	Proportion	(Volume of grains / volume of mixture) Soulsby (1997)
Bulk density of sands	1,590	kg/m^3	2650 kg/m^3 x 0.6
Minimum mass of sand	961,453	kg	605 m^3 x 1590 kg/m^3
Representative mass of sand	1,279,694	kg	805 m^3 x 1590 kg/m^3
Maximum mass of sand	1,661,391	kg	1,045 m^3 x 1590 kg/m^3

3.3.3 Dredging rates

The representative specifications and other assumptions used in relation to the MFE dredging activities are presented in Table 4.

Table 4.   Dredging rates and initial SSC

Quantity	Value	Unit	Notes
Dredging rate			
Minimum time to complete excavation of one HDD exit pit	12	hours	Conservative assumption provided by TKOWFL
Average sediment release rate for fines based on minimum pit volume	4.20	kg/s	181,406 kg / (12hr*60min*60s)
Average sediment release rate for fines based on representative pit volume	5.59	kg/s	241,452 kg / (12hr*60min*60s)
Average sediment release rate for fines based on maximum pit volume	7.26	kg/s	313,470 kg / (12hr*60min*60s)
Average sediment release rate for sand based on minimum pit volume	22.26	kg/s	961,453 kg / (12hr*60min*60s)
Average sediment release rate for sand based on representative pit volume	29.62	kg/s	1,279,694 kg / (12hr*60min*60s)
Average sediment release rate for sand based on maximum pit volume	38.46	kg/s	1,661,391 kg / (12hr*60min*60s)
Rate of water flow from MFE at 100% capacity	4	m^3/s	4000 l/s / 1000 l/m^3
Rate of water flow from MFE at 50% capacity	2	m^3/s	4000 l/s x 50% / 1000 l/m^3
Initial suspended sediment concentrations			
Maximum initial SSC* for fines based on minimum pit volume	2,100	mg/l	(4.20 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Maximum initial SSC* for fines based on representative pit volume	2,795	mg/l	(5.59 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Maximum initial SSC* for fines based on maximum pit volume	3,628	mg/l	(7.26 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Maximum initial SSC* for sand based on minimum pit volume	11,128	mg/l	(22.26 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Maximum initial SSC* for sand based on representative pit volume	14,811	mg/l	(29.62 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
Maximum initial SSC* for sand based on maximum pit volume	19,229	mg/l	(38.46 kg/s / 2 m^3/s water) * 1,000 (1 kg/m^3 = 1,000 mg/l)
* SSC within a few metres of the active MFE working area.			

The rate of sediment release (mass per unit time) is determined by the fixed mass of sediment to be excavated and the time to complete the work. The initial plume concentration (mass per unit volume) is conservatively determined by considering the rate of sediment release with the minimum volume of water introduced to the pit by the MFE to displace that sediment. Assuming a longer time to complete the excavation and/or a higher rate of flow from the MFE would result in a proportionally lower sediment release rate and/or initial SSC.

3.3.4 SSC resulting from MFE dredging of sediment from the HDD exit pits

A spreadsheet based plume dispersion model is provided in Table 5 and Table 6 to describe the reduction in SSC within the plume resulting from the gradual dredging of fine and sand sediments from the HDD exit pit over a 12 hour period. The initial dimensions of the plume section correspond to the distance that water is being advected by tidal currents over one second (0.3 m) and to the smallest total volume of water used by the MFE to mobilise sediment (2.6 x 2.6 x 0.3 m = 2 m^3, yielding the maximum concentration). The mass of sediment suspended in this volume of water is based on the details for the maximum pit volume dimensions provided in Table 4. Other dispersion scenarios shown in the table represent the gradual dispersion of the initial plume with time and distance downstream, which increases the total volume of water within the plume resulting in a corresponding reduction in average SSC.

Table 5.   **SSC in plume resulting from dredging fines based on maximum pit volume**

Scenario: Punch Out Sudden Release Under Pressure	Plume Width (m)	Plume Height (m)	Plume Length (m)	Resulting SSC (mg/l)
Source concentration (continuous plume, per second of release)	2.6	2.6	0.3	3,628
Vertical and horizontal diffusion to 5 m wide and 5 m high.	5	5	0.3	560
Vertical and horizontal diffusion to 10 m wide and 10 m high.	10	10	0.3	140
Vertical and horizontal diffusion to 50 m wide and 10 m high.	50	10	0.3	28
Vertical and horizontal diffusion to 100 m wide and 10 m high.	100	10	0.3	14

Table 6.   **SSC in plume resulting from dredging sands based on maximum pit volume**

Scenario: Punch Out Sudden Release Under Pressure	Plume Width (m)	Plume Height (m)	Plume Length (m)	Resulting SSC (mg/l)
Source concentration (continuous plume, per second of release)	2.6	2.6	0.3	19,229
Vertical and horizontal diffusion to 5 m wide and 5 m high.	5	5	0.3	2,967
Vertical and horizontal diffusion to 10 m wide and 10 m high.	10	10	0.3	742
Vertical and horizontal diffusion to 50 m wide and 10 m high.	50	10	0.3	148
Vertical and horizontal diffusion to 100 m wide and 10 m high.	100	10	0.3	74

The initial plume at the site of the dredging will have a very high SSC but will have a correspondingly small footprint and will only be present while dredging is active. The plume will subsequently be advected in the general direction and speed of the ambient currents at the time of the release and will be gradually dispersed both horizontally and vertically by the natural processes of diffusion.

The dimensions and so the volume of the plume will increase as it is laterally and horizontally dispersed over time. The mass of sediment in any discrete section of the plume is finite and so SSC will become diluted and reduced in proportion to the increase in plume section volume. The spreadsheet model shows that SSC will be reduced to naturally occurring average background levels when the plume has a footprint in the order of 100 m across. It is noted that naturally occurring background SSC can be much higher (hundreds to thousands of mg/l) during relatively frequently occurring storm events.

The time required to achieve such dispersion cannot be calculated with certainty but is estimated to be in the order of tens of minutes to a few hours based on normal tidally induced turbulence. If waves are active at the time of the release, wave induced turbulence at the seabed and wave breaking nearshore would result in much higher rates of dispersion and so reduced SSC in the plume, and also naturally higher levels of background SSC.

The mass of sediment is assumed to remain unchanged in this model, which is realistic for fine material that may take at least hours, if not days or longer to settle out of suspension under suitable conditions.

The settling rate for medium sands is approximately 0.05 m/s (Soulsby, 1997), meaning that such material might settle out of suspension through the representative local water of 10 m in a matter of 3 to 4 minutes. During this time the plume might be advected approximately 50 to 150 m by the typical range of tidal current speeds. A lower height of resuspension or a smaller water depth would proportionally reduce this estimate of time and distance. If any sediment does settle out of suspension more rapidly, then SSC in the plume would be reduced accordingly. In practice, a mixture of grain sizes are likely to be present.

It is noted that the HDD exit point will be approximately 600 to 1250 m offshore of the beach. The currents advecting the plume are aligned parallel to the coast and so it is reasonable to assume that the plume will largely remain a similar distance offshore and therefore may not overlap the nearby (nearshore) bathing water areas at all. If the plume experiences sufficient lateral diffusion to reach the adjacent shoreline, then Table 5 demonstrates that the corresponding SSC would be very low (within the range of naturally occurring values).

Although the plume may be created continuously over of a matter of hours to a day, the path of the plume will naturally vary due to turbulence and flow reversal during flood and ebb tidal periods. It is likely that any location more than a few tens of metres from the point of release would only be affected intermittently and temporarily by the plume.

The plume as a whole would only be potentially present in the nearby bathing water areas (400 and 850 m away) during the time that dredging is active and that the currents are towards that site from the dredging area, i.e. whether flood or ebb conditions, and so at most for only half the time when dredging (approximately 6 to 12 hours at each bathing waters site per pit). Only one of the bathing water locations would be affected at any given time. The plume SSC is expected to become dispersed to less than background levels within a relatively short time/distance and so is unlikely to measurably persist for more than one tide.

3.3.5 Maximum thickness of sediment deposits

Finer sediment disturbed by the MFE dredging will be held in suspension for days to weeks or longer before settling. In this time, the individual grains will become dispersed widely over very large areas and so will not result in any measurable thickness of sediment accumulation or change in sediment type or texture.

Sand sized or coarser sediment disturbed by the MFE dredging will be deposited more rapidly to the seabed around the HDD exit pit. Various calculations are provided in Table 7 that consider different local sediment deposition scenarios. The total volume of sediment that might be redeposited is the same as the volumes of sediment (for each pit dimensions scenario) described in Table 3. The area of the deposit is conservatively and realistically limited to the length of the pit (i.e. the width of the disturbed area across the tidal axis). As described in Section 3.3.4, the maximum likely distance for sand to be transported before being deposited is approximately 50 to 150 m.

Table 7.   Maximum average thickness of consolidated sand sediment

Deposit Width (m)	Deposit Length (m)	Average Accumulation Thickness (m) for Pit Volume:		
		Minimum	Representative	Maximum
75	10	0.81	1.07	1.39
75	50	0.16	0.21	0.28
75	100	0.08	0.11	0.14
75	150	0.05	0.07	0.09

Although the final distribution of the dredged sediment (and so the shape and dimensions of the resulting deposit) cannot be predicted with certainty, the average thickness to which sediment might accumulate (most likely in the order of less than tens of centimetres) is small in absolute and relative terms.

The dimensions in Table 7 are for the sediment volume excavated from a single HDD pit. It is possible that the deposit from one pit may overlap spatially with that of the other, however, the distance between the pits would require a relatively large deposit length to achieve overlap. In this case, the combined average thickness of an overlapping deposit would remain small in absolute and relative terms.

4   Conclusions

The results show that the disturbance of sediment by the planned MFE dredging operations will result in a localised and temporary plume of elevated SSC, comprising the naturally present sediment that is both from, and is being returned to, the ambient sediment transport regime. Where the plume has measureable SSC that might be of concern to bathing water quality or designations, the duration and spatial extent of the plume will be correspondingly small in absolute and relative terms (order of metres over a period of days or order of tens of metres over a period of seconds to minutes).

The HDD exit pit is located approximately 600 to 1250 m offshore of the beach. Any plume will be advected in the direction of the ambient tidal currents, which are aligned parallel to the coast and therefore are likely to remain a similar distance offshore. The plume would be dispersed to relatively low concentrations within hours of the cessation of dredging and to below background concentrations within a few tidal cycles.

Finer sediments are expected to remain in suspension for extended periods of time and will be widely dispersed before settling. Therefore, finer sediment is not expected to accumulate anywhere in measurable thicknesses. If, however, coarser sediment does accumulate around the HDD exit pit, the thickness and footprint of that effect is inherently limited by the volume of the pit and the sediment being excavated.

5   References

ABPmer (2014). Triton Knoll Electrical System Marine Physical Environment: Baseline Assessment (Annex 6-1). ABP Marine Environmental Research Ltd, Report R.2277.

Admiralty (2018). Admiralty Total Tide Software.

Soulsby, R. (1997) Dynamics of Marine Sands. Thomas Telford, London. pp 249.

VBNK (2018). Triton Knoll Offshore Wind Farm Project: HDD Method Statement.

Whitehouse, R., Soulsby, R., Roberts, W. and Mitchener, H. (2000). Dynamics of estuarine muds. Thomas Telford, London. pp 210.

APPENDIX C: CONSULTATION SUMMARY

Para	MMO Comment 10/09/18	TKOWFL Response 24/10/18
1	The MMO acknowledges that vessel disturbance for ornithology and marine mammals has previously been assessed within the Environmental Statement (ES) and has therefore been screened out from further assessment, however the MMO would like to bring attention to the Red Throated Diver code of conduct, we ask that Triton Knoll's contractors are made aware of this and adhere to it. Please see Annex 1. The MMO agrees with the remaining screening outcomes as displayed within table 4.1.	TKOWFL note the comment and confirm that a statement has been included in the HDD EIR in Section 4.1, full details of the Code has also been included in the CMS for the proposed works.
2	The MMO agrees with the suggestions made by the model predicting the bentonite concentrations which indicates that the release would have an insignificant impact on the nearby bathing waters. Therefore the MMO is satisfied that the information provided is adequate to satisfy the considerations of the discharge of up to 10 tonnes of bentonite and drilling cuttings released forcefully and suddenly under pressure, and also at a gradual rate of 20 tonnes per 24 hours not under pressure. Further from this, we would encourage the use of the HDD methodology under the gradual release scenario. This would reduce the works footprint further and the release of material into the environment	TKOWFL note the comment. No update to the report required.

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Para	MMO Comment 10/09/18	TKOWFL Response 24/10/18
3	The MMO request further evidence in respect of the impacts of the excavation of the exit pit construction to be provided. At present no modelling data has been provided on the excavation of the exit point using a backhoe dredger (or similar). It can be seen from table 3 and table 4 that the maximum exit pit volume to be removed is nearly 10 times as much material than is expected to be release on punch out (bentonite release) and should therefore be treated as the most important activity. If you feel that previous evidence that demonstrates that the impacts from this activity will not affect bathing waters has already been provided as part of the Environmental Impact Assessment, please provide a signposted document to refer us to the relevant chapters	TKOWFL note the comment and can confirm that additional text has been included in Section 4.3.2 of the HDD EIR, which provides context and comparison of the proposed HDD exit pit excavation with the cable installation activities assessed within the TK Electrical System Environmental Statement (ES). In addition, further detail from the ES assessments has been included and signposted in Sections 4.2.2 and 4.3.2.

TKOWFL highlight that an addition section has been added to include the use of a Mass Flow Excavator (MFE) to clear any sediment that may be deposited within the excavated exit pits during the period between initial excavation and subsequent offshore export cable installation.

The headings of these sections within the HDD EIR have been amended to clarify that they refer to the proposed excavation and subsequent re-excavation activities. |
| 4 | The MMO acknowledge that the full construction method statement is to follow later in 2018, however this report does not make it clear where the dune system, which forms the sea defence, lies in relation to the HDD. Further clarification on this is required. The MMO would expect to see a cross section showing the dune system, HDD profile and the entrance and exit drill points | The location of the sand dunes is indicated on an updated version of Figure 1-3 within the HDD EIR. A cross sectional profile of the HDD, providing drill profile and relevant depths in relation to the sand dune system and subsurface geology is provided at Appendix D, reproduced from Appendix 2, Figure A2.1; Conceptual Model of the Triton Knoll Review of HDD proposals for buried cable; Risk assessment for Environment Agency, dated 28th August 2018 (Document No. 2505-GCG-ENG-Q-RA-2721341-02). The conceptual model has been agreed with the Environment Agency (EA) and will be updated with detailed design information, which will be agreed with the EA in advance of the HDD works commencing. |

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Para	MMO Comment 10/09/18	TKOWFL Response 24/10/18
5	We understand the landward side drilling locations will remain the same, but the moving of the proposed exit points offshore below Mean High Water Springs will have an impact on the drill profile and impacts from this must be considered as part of the submission of the Construction Method Statement. As part of this, the MMO require clarification on the proposed depth of drilling below the sand dunes, which form the sea defence at this location.	TKOWFL acknowledge the comment and confirm that the conceptual model of the drill profile provided at Appendix D provides information available at this stage. The drill depth is likely to be between 15 and 20m and this has been agreed with the EA. The HDD will be designed to avoid drilling into the chalk, however the EA have advised they are comfortable that a clearance distance is not required between the drill and the aquifer as the drill appropriately mitigates any risk should the chalk be encountered during the drill. Please refer to the EA Risk Assessment. Detailed design, will be provided following analysis of the borehole data in advance of the HDD activities commencing. This will be provided to the EA for reference and sign-off.
6	Additionally, the MMO would like to see considerations of the impacts of the leaking of bentonite beneath the dune system and what measures will be put in place to mitigate against this risk.	Additional summary text has been added to this document (see Section 2.5), with detailed information and assessment relating to potential pollution pathways, together with relevant control measures, provided within the EA Risk Assessment (Document No. 2505-GCG-ENG-Q-RA-2721341-02).

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APPENDIX D: CONCEPTUAL MODEL (*EXTRACT FROM DOCUMENT NO. 2505-GCG-ENG-Q-RA-2721341-02*)
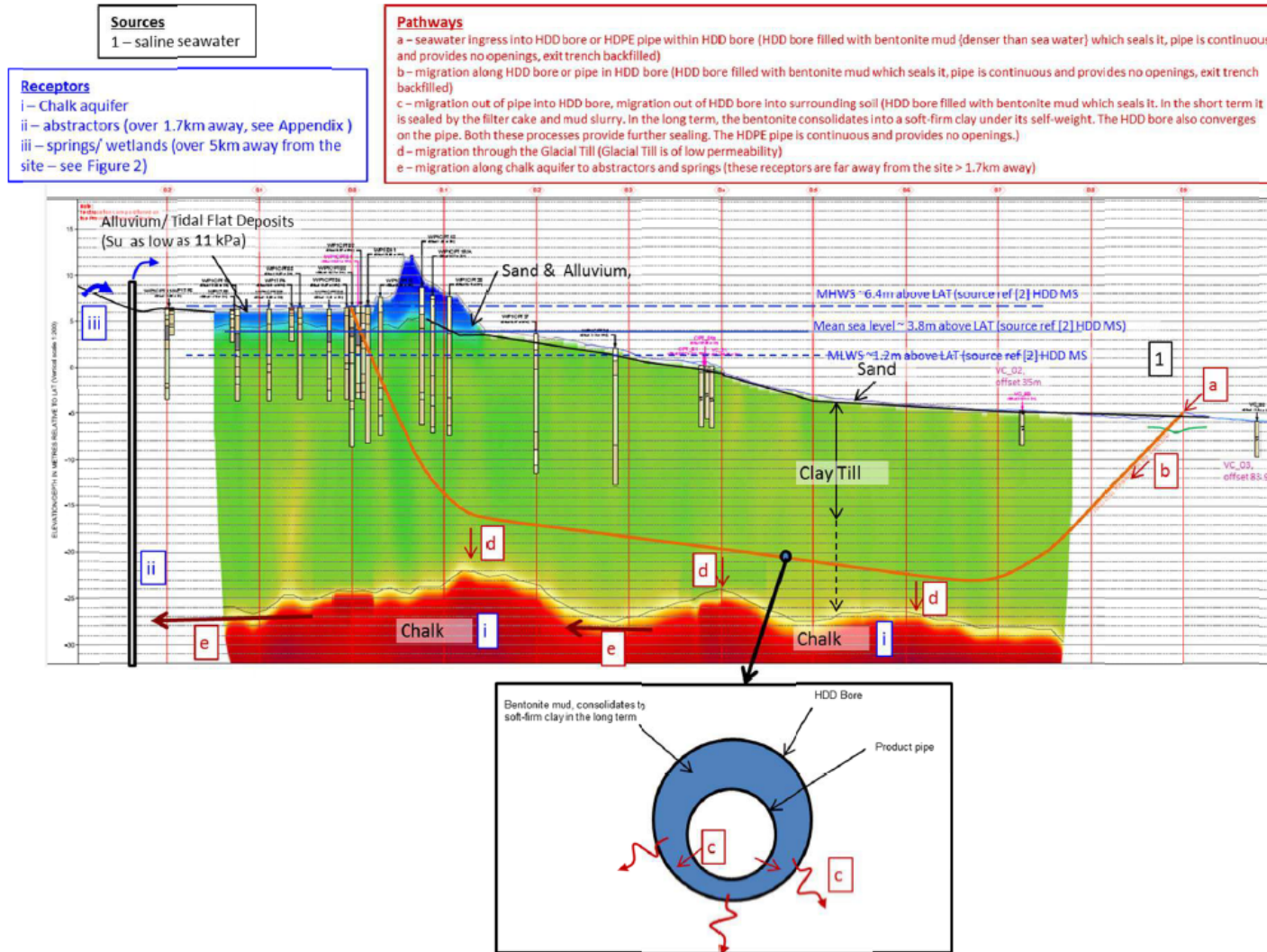
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