Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Environmental Statement

Volume 3

Appendix 3.2 - Cable Landfall Concept Study

August 2022
Document Reference: 6.3.3.2
APFP Regulation: 5(2)(a)

China Resources
Better Life Together

Masdar
A MUBADALA COMPANY

equinor

Title: **Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects Environmental Statement Appendix Cable Landfall Concept Study**		
PINS Document no.: 6.3.3.2		
Document no.: C282-MU-Z-GA-00001		
Date:	Classification	
August 2022	**Final**	
Prepared by:		
Murphys		
Approved by:	Date:	
Sarah Chandler, Equinor	August 2022	

EXTENSION OF THE DUDGEON AND SHERINGHAM SHOAL OFFSHORE WIND FARMS

CABLE LANDFALL CONCEPT STUDY

Produced for:

EQUINOR

Document No.	1002-000330-MAE-XX-XX-RP-C-0001
Revision:	P01
Date:	28th February 2020

J Murphy and Sons Ltd
1 Bridge Court
Stonecross Business Park
Golborne
Wigan
WA3 3JD

Record of Issue

Revision	Description	Originator	Reviewed	Approved
P01	Client Review	SB	MP	JC

Record of Change

Page No	Description of Change

Hold

Page No.	Hold item

CONTENTS

1.0 Introduction

1.1 General

In 2018 The Crown Estate invited developers to bid for extensions to operating Round 2 offshore wind farms. Equinor has, on behalf of the partners in the existing wind farm projects, applied for an Agreement for Lease (AfL) for the extension of the Dudgeon and Sheringham Shoal offshore wind farms.

A grid connection offer from National Grid to accommodate both Projects was secured in May 2019. As a result, both extension projects will connect to the existing electricity grid at Norwich Main substation.

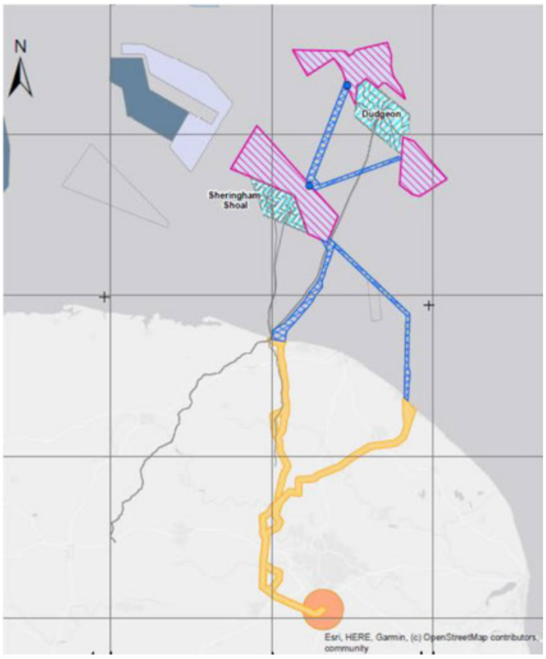


Figure 1.0. Proposed Dudgeon and Sheringham Shoal extensions area and routing alternatives.

Company is planning a development of up to approximately 800 MW installed wind turbine generation capacity.

The Project comprises the following main elements:

- 800MW installed power capacity.
- Offshore wind turbine generators.
- Offshore substation(s).
- Infield cables connecting the wind turbines to the offshore substation.
- Offshore export cables to the landfall (including fibre optic cable).
- Onshore export cables from the landfall transition joint bay to the onshore substation.
- Onshore substation.
- Onshore cables connection the existing Norwich main substation.

The offshore export cables will be connected to the offshore electrical platform(s) within the proposed Projects to shore, making landfall at Weybourne or Bacton.

For the Landfall two parallel export cables are planned, pulled in through individual ducts made by Horizontal Directional Drilling (HDD) under the beach zone.

The proposed development will include a single onshore cable corridor which will contain two buried cable circuits for both Projects. Both Projects will be connected to the National Grid at the existing Norwich Main substation in Norfolk.

1.2 Abbreviations

Abbreviations	
Abbreviation	***Definition***
AfL	Agreement for Lease
HDD	Horizontal Directional Drilling
JMS	J Murphy & Sons Ltd
OD	Outside Diameter
WT	Wall Thickness
SMYS	Specified Minimum Yield Strength
SMP	Shoreline Management Plan
NCERM	National Coastal Erosion Risk Mapping
SSSI	Site of Special Scientific Interest
MCZ	Marine Conservation Zone
SAC	Special Area of Conservation
SAP	Special Protection Area
BAP	Biodiversity Action Plan

1.3 Proposed Landfall Locations

Two locations are being considered for the cable landfalls, at each location there are two options as follows:

- Bacton
  - East of Bacton Gas Terminals
  - West of Bacton Gas Terminals.

- Weybourne
  - West - near to Sheringham Shoal and Dudgeon landfall
  - East - between Sheringham and Weybourne

1.3.1 Landfall at Bacton

The proposed Bacton West landfall is the preferred location and is located West of the Bacton Terminal. The alternative location, Bacton East is located East of the terminal. See Figure 1.2 and 1.3 below for the locations and potential HDD alignment at Bacton.

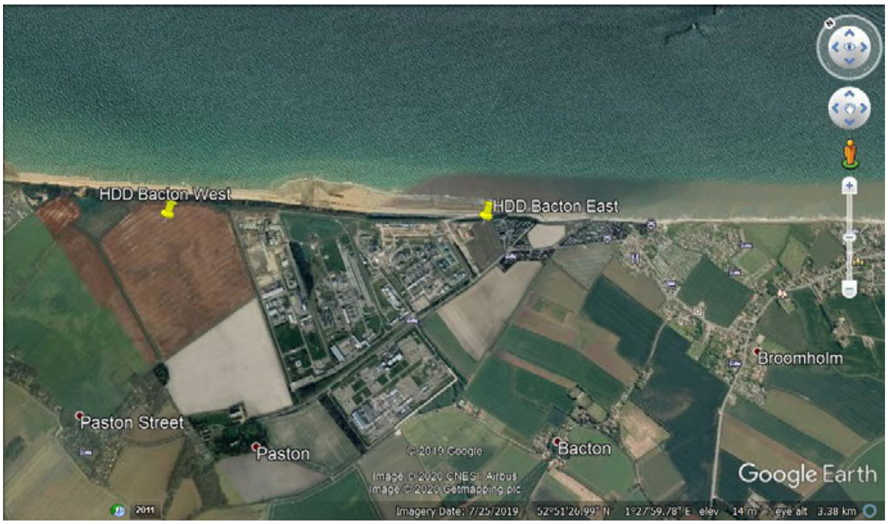


Figure 1.2. Landfall location options at Bacton.

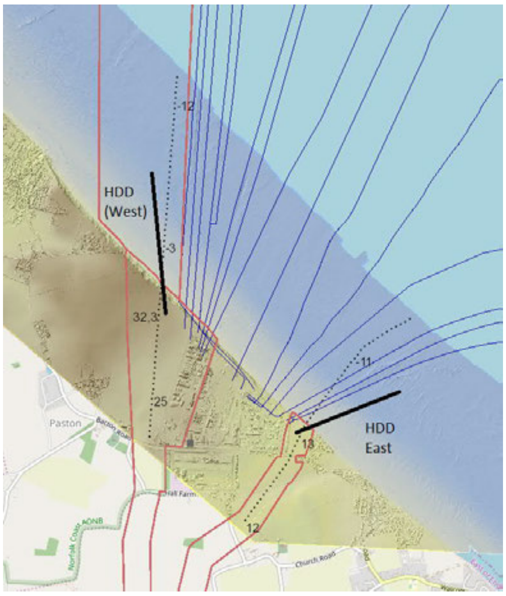


Figure 1.3. Potential HDD alignment at Bacton.

HDD entry point (current estimated elevation above sea level) is 32m for the HDD West option and 15m for the HDD East option.

1.3.2 Landfall at Weybourne

The proposed Weybourne West Landfall is the preferred location and is located east of the existing Dudgeon cable landfall. The alternative location, Weybourne East is located between Weybourne and Sheringham See Figure 1.4 and 1.5 below for the locations and potential HDD alignment at Weybourne.

Figure 1.4. Landfall location options at Weybourne.

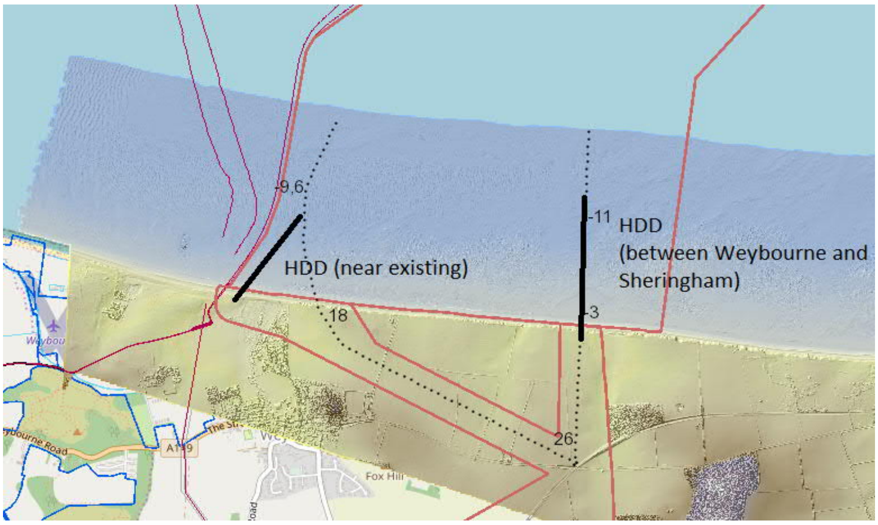


Figure 1.5. Potential HDD alignment at Weybourne.

HDD entry point (current estimated elevation above sea level) is 8m for the HDD West option and 15m for the HDD East option.

2.0 Published Information

2.1 Published Geology (Bacton)

Published geological data presented in this section has been obtained from the British Geological Survey Geology of Britain Viewer website (http://mapapps.bgs.ac.uk/geologyofbritain/home.html)

Superficial deposits in the vicinity of the proposed landfall are indicated to comprise the following deposits:

- Marine Beach Deposits
- Briton's Lane Sand and Gravel Member
- Bacton Green Till Member
- Happisburgh Glaciogenic Formation

Bedrock geology is mapped as the Crag Group, a sedimentary deposit of coarse to fine grained interbedded sequences of Sand and Gravel deposited in estuarine or shallow marine conditions.

No linear geological features or faults are indicated on the available mapping.

2.2 Ground investigations (Bacton)

Ground investigation related to the landfall is not currently available. Limited historical data is available from the British Geological Survey GeoIndex ([redacted]). The closest historical boreholes to the proposed landfall are located <500m away within Bacton Gas Terminal and on the beach immediately adjacent to the Gas Terminal.

The boreholes indicate a sequence of medium dense to dense Sands with soft to stiff Clay bands. Medium hard Chalk (Grade IV to III) is proven in one borehole at -11.18m AOD or 15.4m below beach level at the time of drilling.

2.3 Environmental Data (Bacton)

Environmental data was obtained from the Environment Agency and Natural England's Magic Websites shown respectively as:

- https://magic.defra.gov.uk/
- https://www.gov.uk/government/organisations/environment-agency

Both the Bacton East and Bacton West landfall locations have been assessed; one West of the existing pipelines running out of the Bacton terminal and one on the East side of the existing subsea pipelines.

The landfalls are not considered to be at risk of flooding from rivers or the sea and are not in a flood warning area.

There are no known historic landfill areas at the proposed landfall locations or in the surrounding areas. At Bacton terminal, there were a total of 13 air and controlled water pollution incidents recorded in 2018.

The landfalls are not within a groundwater protection zone and don't lie within a nitrate venerable zone, however the West HDD option is located in a field that borders a nitrate vulnerable zone.

The section of Norfolk coastline is subject to coastal erosion. It is a continual process that is likely to be accelerated by rises in sea levels. A Shoreline Management Plan (SMP) has been developed by the Environment Agency for Kelling to Lowestoft that covers the section of coastline to be crossed by the proposed landfalls. The SMP indicates a coastal management policy for the short, medium and long term. The design life of the cable is assumed to be 30 years so the anticipated erosion profile associated with the medium term (20-50years) will be considered when designing the landfalls. The data in the table in below is taken from the National Coastal Erosion Risk Mapping (NCERM) – National (2018-2021) tool on the Environment Agencies website (http://apps.environment-agency.gov.uk/wiyby/134808.aspx):

Shoreline Management Plan Name	Defence Type	Feature Type	Medium Term SMP Policy	Retreat Distance in Meters for Medium Term with No Active Intervention at 95%-ile confidence	Retreat Distance in Meters for Medium Term SMP Policy Intervention at 95%-ile confidence
Kelling Hard to Lowestoft (North Norfolk)	Revetment	Erodible	Managed Realignment	65.00	65.00

Table 2.1 – SMP for Kelling Hard to Lowestoft (where the HDD's cross the cliff).

The Bacton West landfall crosses land designated as a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act (1981).

The landfall will exit in a designated Marine Conservation Zone (MCZ) which protects nationally important marine wildlife, habitats, geology and geomorphology. MCZ's are designated under the Marine and Coastal Act (2009).

The landfall also exits in a Special Area of Conservation (SAC) designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora.

The upper beach and intertidal zone are a Special Protection Area (SPA) which is a site containing regularly occurring migratory species that are dependent on the marine environment for all or part of their life cycle.

The cliff tops at the landfall location are designated as a Priority Habitat under the Environment and Rural Communities Act (2006) Section 41 habitats of principal importance. This replaces Natural England's previous separate Biodiversity Action Plan (BAP).

The Bacton East landfall has the same environmental designations as the West option, however it doesn't cross the designated SSSI. All other designations associated with the MCZ, SAC, SPA and Priority Habitats apply.

The onshore drill site for both landfall options will be positioned in an Area of Outstanding Natural Beauty (AONB). These are designated areas to protect and manage the areas for visitors and local residents. Natural England have designed these areas under the Countryside and Rights of Way Act 2000.

2.4 Subsea Pipeline Infrastructure (Bacton)

The landfall options at Bacton are located either side of the subsea pipelines that run into Bacton terminals. The Bacton East option would be required to cross these pipelines as part of the offshore route. Table 2 provides information relating to the pipelines and is taken from the Oil and Gas Authority website ([redacted]):

PIPE_NAME	DIAMETER	UNITS	FLUID	OPERATOR
LEMAN 49/26-BT TO BACTON	30	inch	GAS	SHELL
SHEARWATER TO BACTON (SEAL)	34	inch	GAS	SHELL
BACTON TO LANCELOT	3	inch	CHEMICAL	PERENCO
LEMAN AP TO BACTON	30	inch	GAS	SHELL
LEMAN BT TO BACTON A2	30	inch	GAS	PERENCO
LEMAN 49/27 AP TO BACTON A1	30	inch	GAS	PERENCO
HEWETT SOUTHERN EXPORT A-LINE TO BACTON	30	inch	GAS	ENI
HEWETT NORTHERN EXPORT B-LINE TO BACTON	30	inch	GAS	ENI
ESMOND TO BACTON	24	inch	GAS	PERENCO
LANCELOT TO BACTON	20	inch	GAS	PERENCO
BACTON TO ZEEBRUGE			GAS	INTERCONNECTOR
BACTON TO CLIPPER PT	3.5	inch	CHEMICAL	SHELL
SEAN P TO BACTON TERMINAL	30	inch	GAS	DYAS UK LIMITED
CLIPPER PT TO BACTON	24	inch	GAS	SHELL
BBL BALGZAND TO BACTON			GAS	BBL
BACTON TO LEMAN AP	4	inch	CHEMICAL	SHELL
BACTON TO THAMES	24	inch	GAS	ODE

Table 2.2 – Subsea Pipelines at Bacton Terminal

2.5 Published Geology (Weybourne)

Published geological data presented in this section has been obtained from British Geological Society Geoscience Data index website ([redacted])

Superficial deposits in the area of the proposed landfall are indicated to comprise the following deposits:

- Briton's lane sand and gravel member,
- Head deposits, comprising clay, silt, sand and gravel,
- Beach deposits comprising sand and gravel,
- Lowestoft Formation – Chalky till with outwash sand & gravel, silts and clays characterised by its chalk and flint content. The flint content is understood to be up to cobble and boulder sized nodules.

An area of disturbed undivided artificial ground of unknown/unclassified entry is recorded at the proposed West landfall location.

No faults or other linear geological features are indicated at the West landfall location.

Solid deposits are indicated to comprise an undifferentiated series of chalk from the Lewes nodular chalk formation, Seaford chalk formation, Newhaven chalk formation, Culver chalk formation and Portsdown chalk formation all Upper Cretaceous in age.

2.6 Ground investigations (Weybourne)

Limited historical ground investigation data is available within the public domain. The following data has been obtained from the British Geological Survey Geoscience Data index ([redacted]. The closest historical boreholes to the landfall location, are some 500m away. These indicate a sequence of superficial deposits comprising sand, gravel, sand and gravel, yellow clay and boulder clay overlying bedrock. Chalk bedrock was encountered in all boreholes at depths ranging from 24m to 55m below existing ground level.

A geophysical seismic survey report undertaken by Terra Dat for Sciria Offshore Energy, titled Seismic Survey Landfall, reference SC-00-NN-Y15-00004, dated October 2008 at Weybourne beach, North Norfolk for the Sheringham Shoal project was obtained from the Dudgeon landfall study undertaken by Land and Marine Engineering Ltd in 2013. The results of this survey report indicate four distinct velocity layers to be present within the subsurface as follows:

- Layer 1: Weak near-surface material (dry loose sediments and fill),
- Layer 2: Compact unsaturated sediment (head, weathered till and beach sediments),
- Layer 3: Dense glacially compacted sediments (Lowestoft formation),
- Layer 4: Likely chalk bedrock.

It is noted within the report that some significant lateral variability in material types may be encountered in proximity to the layer 3/4 boundary where glacially compacted outwash sands at the base of the Lowestoft Formation may be found in close proximity to a weathered/transitional chalk layer.

Model seismic sections included in this report indicate layer 1 and layer 2 to be present above the shoreline up to 10m in thickness. Layer 3 is indicated to be relatively uniform and around 10m to 15m in thickness and is present across the entirety of all survey lines.

Layer 4 likely chalk bedrock is present in all survey lines directly below layer 3. The likely chalk bedrock was encountered at around 15 to 20m below ground level onshore and around 20m below the seabed offshore.

Two borehole logs undertaken by RSA Geotechnics Ltd for Visser & Smit Global Marine contracting under RSA job reference 11847 in May 2009 has been obtained from the previous Dudgeon HDD landfall study Land and Marine Engineering Ltd conducted in 2013. The investigation comprised two boreholes undertaken for the Sheringham Shoal Windfarm project to 30m depth. The boreholes were land based and located either side of the proposed landfall location.

These boreholes indicate the ground to predominantly comprise a sequence of gravelly sand overlying chalk bedrock. The chalk bedrock was encountered at 15.30m and 25.50m below ground level indicating considerable variability in rockhead level. The top of the chalk is indicated to be highly weathered and is described as fragmented with sand layers. The chalk bedrock was generally described as off-white weathered structureless chalk.

2.7 Environmental Data (Weybourne)

At Weybourne two landfall options exist. The Weybourne West option is close to the existing Dudgeon landfall and the alternative Weybourne East location is approximately 1700m further east along the coast towards Sheringham. The elevation of the cliffs gradually climbs from the Weybourne West to Weybourne East.

The landfalls are not considered to be at risk of flooding from rivers or the sea and are not in a flood warning area. There are no known historic landfill areas at the proposed locations or in the surrounding areas.

The landfalls are not within a groundwater source protection zone but are within a nitrate vulnerable zone.

Table 2 shows the anticipated erosion figures of the cliffs at the proposed HDD location taken from the National Coastal Erosion Risk Mapping (NCERM) tool on the Environment Agencies website (http://apps.environment-agency.gov.uk/wiyby/134808.aspx).

Shoreline Management Plan Name	Defence Type	Feature Type	Medium Term SMP Policy	Retreat Distance in Meters for Medium Term with No Active Intervention at 95%-ile confidence	Retreat Distance in Meters for Medium Term SMP Policy Intervention at 95%-ile confidence
Kelling Hard to Lowestoft (North Norfolk)	Revetment	Erodible	No active intervention	10.00	10.00

Table 2.3 – SMP for Kelling Hard to Lowestoft

Weybourne East crosses an area designated as a SSSI, However Weybourne West avoids the area classified as SSSI. The onshore sites for both options sit within an AONB.

The landfalls cross or exit in an MCZ and SPA designated area. Both options avoid marine SAC designated areas.

The cliff tops at both HDD locations are designated as a Priority Habitat under the Environment and Rural Communities Act (2006).

2.8 Anecdotal Information (Weybourne)

The onshore site for the Weybourne West option is likely to be positioned in close proximity to a former wastewater treatment plant, the possibility exists that there may be existing foundations still present from demolition of the site. It will be prudent to undertaken localised investigations to ensure no foundations remain in the proposed areas of construction. Fig 2.1 shows the wastewater treatment plant and the proposed HDD alignment which is detailed further in drawing 1002_000330-MAE-XX-XX-DR-C-0003 in Appendix D. The image is taken from Google Earth historical imagery from 1999.

Figure 2.1 – Position of historical wastewater treatment works

3.0 Site Visit

A site visit was performed by JMS personnel on Tuesday 18th February 2020 and Wednesday 19th February 2020. The weather during the visit was dry with slight winds.

3.1 Bacton East HDD

The East landfall at Bacton has an elevation difference of approx. 8m and the proposed HDD rig site is in a level field with a caravan park situated in proximity. The cliff had a fence running along the top with a sign warning the general public of the erosion. Photographs taken during the visit are shown below:

Fig 3.1A. Proposed HDD Entry Point.

Fig 3.1B. Embankment fenced off due to erosion.

Fig 3.1C. Access from the B1159 Coastal Road.

Fig 3.1D. Cliff condition at beach level.

Fig 3.1E. Cliff condition at beach level.

3.2 Bacton West HDD

The West landfall at Bacton is located at the top of a cliff with an elevation difference of approx. 32m. The proposed HDD rig site would be situated on a level field which slopes slightly towards Bacton Terminal. Photographs taken at during the visit are shown below:

Fig 3.2A. Proposed HDD Entry Point.

Fig 3.2B. Top of cliff looking down to the beach.

Fig 3.2C. Field accessible with plant

Fig 3.2D. Cliff condition and beach level at HDD.

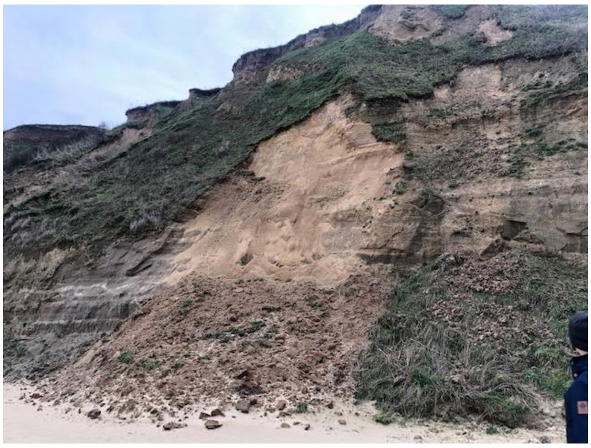


Fig 3.2E. Cliff condition at beach level.

Fig 3.2F. Cliff condition at beach level.

3.3 Weybourne East HDD

The East landfall at Weybourne is situated at the top of a cliff face with an elevation difference of approx. 15m. The proposed HDD rig site location is situated within a level field which slopes off towards the South East. Photographs taken during the visit are shown below:

Fig 3.3A. Landscape at HDD entry location.

Fig 3.3B. Car park West of HDD entry location.

Fig 3.3C. Footpath at top of cliff face.

Fig 3.3D. Cliff face condition from top of cliff.

3.4 Weybourne West HDD

The West landfall at Weybourne is situated at the top of a cliff face with an elevation difference of approx. 8m. The proposed HDD rig site location would be situated within a level field local to the previous Sheringham Shoal and Dudgeon landfalls. During the visit there was no access to the field where the HDD rig site would be situated, therefore all photographs taken where via a public footpath located at the top of the cliff. Photographs taken during the visit are shown below:

Fig 3.4A. Proposed HDD entry point.

Fig 3.4B. Looking out to sea from cliff top

Fig 3.4C. Cliff face condition.

Fig 3.4D. Beach and cliff view.

Fig 3.4E. Cliff face condition.

Fig 3.4F. Sheringham Shoal joint bay location.

4.0 Horizontal Directional Drilling

4.1 Methodology

HDD is a trenchless technique for the installation of pipelines and ducts. HDD is surface launched and is generally considered a more environmentally friendly installation method as surface disturbance is only caused at the drill entry and drill exit location. HDD is regularly used to cross rivers, roads, railways, environmentally sensitive areas and for the installation of landfalls and outfalls. The suitability of HDD or otherwise is dependent on the ground conditions present. For example, ground containing significant quantities of gravel may preclude the use of HDD.

HDD has been undertaken on many occasions worldwide for the installation of landfalls using a land-based HDD rig supported in the latter stages by an offshore marine spread.

It is understood the Sheringham Shoal cable landfalls and Dudgeon cable landfalls were installed by HDD reinforcing the feasibility of the technique in this area.

A typical method statement outlining the operations that would need to be undertaken for the installation of cable duct landfalls by HDD is included in Appendix A.

4.2 Landfall Location Advantages and Disadvantages

The advantages and disadvantages for both HDD landfall locations is summarised in the tables below. Consideration has been given to the access, location, laydown areas for equipment and potential stringing sites for pipeline construction. Drawings associated with the stringing sites and access for the preferred landfall locations can be found in Appendix D:

4.2.1 Bacton – East

Advantages	*Disadvantages*
	Technical – Approximately 15m elevation difference, potential flush onto the seabed of Approx. 47m^3 due to the elevation difference between the HDD entry and the HDD exit locations. Mitigations will need to be in place to manage drilling fluid release.
	Technical **-** Crossing of the existing offshore pipelines into Bacton terminal would require permissions from pipeline owners. It is anticipated this will be a challenging process and a significant amount of work would need to be undertaken to demonstrate that the integrity of the pipelines would be maintained during pipe/cable installation
Technical - Cliffs are lower than at the Bacton West location – Drilling fluid pressures will be lower less chance of breakout	
Technical **-** Offshore pipelines have previously been installed in the area	***Technical*** – HDD has not been adopted to install pipeline into Bacton terminals – No prior reference of success of HDD technique in area

Advantages	*Disadvantages*
Technical - Installation pull loads are within the acceptable limits of cable duct mechanical properties	
	Location - Drill location is close to a residential area - noise mitigation measures should be considered when working 24 hours
Technical - Depth of profile within limits of what cable system can withstand	
Environment - Does not cross SSSI designated area.	***Environment -*** HDD exits in an MCZ, SPA and SAC area. Cliff tops designated as a priority habitat under the Environmental and Rural communities act (2006). HDD rig will be located in an AONB Early Liaison with Natural England required
Access - access for HDD equipment along road controlled by Bacton Terminal off the B1159 Coastal Road provided access is granted by the terminal.	
Topography – The topography around the HDD entry location is flat. Good for access and set up of HDD equipment. Upper beach levels local to this location have been raised to ensure they are not submerged at high tide. This is a potential location for the stringing site, access to the beach will need to be arranged with the terminals	
	Geotechnical - No offshore geotechnical information to confirm HDD profile is in competent ground formation to reduce the risk of a breakout on the seabed.

4.2.2 Bacton – West

Advantages	Disadvantages
	Technical - 32m elevation difference, potential flush onto the seabed of approx. 100m^3 due to the elevation difference between the HDD entry and the HDD exit locations. Mitigation measures will need to be in place to manage drilling fluid release.
	Technical - Downhole pressures required to overcome the differential head and maintain cutting returns to the drill entry pit. Ground conditions will need to accommodate down hole pressures
Technical - Offshore pipelines have previously been installed in the area	***Technical -*** No pipelines installed by HDD for Bacton terminals – No prior use of proposed technique
Technical - Installation pull load within acceptable limits of cable duct mechanical properties.	
	Location - Drill location is less than 1km from a holiday village with properties on the main road - Noise mitigations should be considered when working 24 hours.
	Technical - Depth of profile required reaching limit of what cable system can withstand
	Environment - profile crosses SSSI area and exits in an MCZ and SAC area. Upper beach is in a SPA for migratory species. Cliff tops designated as a priority habitat under the Environmental and Rural communities act (2006). HDD rig will be located in an AONB
Access - Suitable access for HDD equipment via the B1159 Bacton Road, turning onto Vicarage Road and through a privately-owned field. Farming equipment tracks in the field suggests the location will be accessible for the HDD equipment but protection to the field may be required.	

Advantages	Disadvantages
Topography – The topography around the HDD entry location is flat. Good for access and levelling of HDD equipment. Upper beach levels local to this location have been raised to ensure they are not submerged at high tide. This is a convenient location for the stringing site although no direct access to the beach this will be at Bacton East and will need to be arranged with the terminals	
	Geotechnical - No offshore geotechnical information to determine if the HDD profile is in a competent ground formation to reduce the risk of a breakout on the seabed.

4.2.3 Weybourne – East

Advantages	Disadvantages
	Technical - 15m elevation difference, potential flush onto the seabed of approx. 47m^3 due to the elevation difference between the HDD entry and the HDD exit locations. Mitigation measures will need to be in place to manage drilling fluid release.
Technical - Installation pull load within the acceptable limits of cable duct mechanical properties.	
Location - Drill location is in a non-residential area - noise pollution will not be a concern to local residents but should still be monitored.	
	Environment - HDD crosses SSSI area and also HDD exits in an MCZ and SAC area. Upper beach is in a SPA for migratory species. Cliff tops designated as a priority habitat under the Environmental and Rural communities act (2006). HDD rig will be located in an AONB
Access - Access for HDD equipment will be via the A149 Sheringham Road, turning onto an unknown access track and through a privately-owned field. Farming equipment tracks in the field suggests the location will be accessible for	

the HDD equipment but protection to the field may be required.	
	***Location* -** HDD location is close to the Norfolk Coast Path, HDD site will need to be secure from public access.
***Topography* –** The topography around the HDD entry location is flat. Good for access of HDD equipment.	
	***Geotechnical* -** No offshore geotechnical information to determine if the HDD profile is in a competent ground formation to reduce the risk of a breakout on the seabed.

4.2.4 Weybourne – West

Advantages	*Disadvantages*
	***Technical* -** 8m Elevation Difference, potential Flush onto the seabed of Approx. 25m^3 due to the elevation difference between the HDD entry and the HDD exit locations. Mitigation measures will need to be in place to manage drilling fluid release
***Technical* -** Previous landfalls have been installed at the location by HDD	
***Technical* -** Installation pull load within the acceptable limits of cable duct mechanical properties	
	***Location* -** Drill location is approx. 250m from a residential area - Noise mitigations should be considered when working 24 hours.

Advantages	Disadvantages
Environment - Does not cross SSSI area	***Environment -*** HDD Exits in an MCZ and SAC area. Cliff tops designated as a priority habitat under the Environmental and Rural communities act (2006). HDD rig will be located in an AONB
Access - Access for HDD equipment will be via the A149 turning into the Muckleburgh Military Collection Museum. The location has previously been used for the Dudgeon and Sheringham Shoal landfalls.	
Location - HDD location is close to the Norfolk Coast Path, Perimeter of the Muckleburgh Military Collection Museum has barb wire fence line segregating the HDD location from the general public.	
Location – Joint bay is located in close proximity to existing joints bays for Sheringham Shoal and Dudgeon windfarms. Area of sterilised land will be minimised if the onshore cable route is close to the existing route	
Topography – The topography around the HDD entry location is flat. Good for access of HDD equipment.	
	Geotechnical - No offshore geotechnical information to determine if the HDD profile is in a competent ground formation to reduce the risk of a breakout of bentonite onto the seabed.
	Geotechnical – in close proximity to historical wastewater treatment works. Potential for foundations to still be buried on the site

4.3 HDD Location Summary

4.3.1 Bacton

The two locations considered at Bacton have been evaluated in section 4.2. A summary of the locations is discussed below:

- Bacton East is in close proximity to a caravan park and the noise generated from the HDD would be an issue with residents or members of the public on holiday. Bacton East would require offshore crossings of the existing pipelines running into the terminal. This would require meetings with the pipeline owners/operators to discuss crossing methodology. It is envisaged the project risks associated with this option are non-favourable in comparison to the West option. Access to the beach is better for this location. Ownership of the land needs to be considered.

- Bacton West has a larger elevation difference between the HDD entry and exit points. The offshore route would not need cross the existing pipelines. The elevation difference will require a competent HDD contractor and Mud Engineer to monitor the pressure and flow rates to ensure the cuttings are being removed from the bore. The maximum required depth of the crossing is close to the maximum depth the cable system can withstand.

Out of the two locations evaluated, Bacton West is considered to be the most feasible option for the HDD landfall with the main contributing factor being the potential restrictions that may be imposed for crossing the offshore pipelines.

4.3.2 Weybourne

The two locations considered at Weybourne have been evaluated in section 4.2. A summary of the locations is discussed below:

- Weybourne East has the greater elevation difference of the two locations and there is no history of an HDD landfall being performed in the area. Access to the drill site is more challenging than the West option. Access for pipeline stringing launching the duct is more difficult too

- Weybourne West is located in an area where both the Sheringham Shoal and Dudgeon cable landfalls have been successfully installed. The area has also been used for the stringing and launching of the ducts during previous projects.

Out of the two locations evaluated Weybourne West is considered to be the most feasible option for the HDD landfall with the main contributing factors being the lower cliff elevation, previous successful drills and the onshore joint bay being located close to the existing Sheringham Shoal and Dudgeon joint bays.

5.0 Cable and Duct Details

5.1 Cable Details

The following cable data was provided by Equinor for the purposes of this study:

Cable Details	
Cable Diameter	275mm
Weight (In Air)	125 kg/m

Table 5.1. Cable Details.

5.2 Duct Details

The internal diameter and wall thickness of the duct required for cable installation will be dependent on the diameter of the cable pulling head and the thermal dissipation of the cable when it is operational.

The following cable duct details are proposed for this project:

Proposed Duct Details	
Duct Material	HPPE
Grade	PE-100
SDR	11
Outside Diameter (OD)	710mm
Wall Thickness (WT)	64.5mm
Internal Diameter (ID)	581mm
Yield Strength	23 MPa

Table 5.2. Proposed Duct Details.

Analysis of the thermal dissipation should be undertaken to determine if the 710mm duct stated above remains acceptable. If the 710mm diameter duct proves to be unsuitable a duct diameter of 800mm could be considered. A larger duct, whilst still feasible for installation using HDD would present an increase in risk for drilling due to the larger diameter bore that would be required.

6.0 HDD Design

6.1 HDD Profile Design

HDD profiles have been proposed, one for the landfall at Bacton West and one for the landfall at Weybourne West and are presented on drawings 1002_000330-MAE-XX-XX-DR-C-0001 & 1002_000330-MAE-XX-XX-DR-C-0003 in Appendix D.

In designing the HDD profiles the following has been considered:

- Min radius of curvature of drill rods
- Entry angle
- Exit angle
- Future cliff erosion profile
- Depth under the toe of the cliff
- Ground conditions
- Min water depth at exit to accommodate cable lay barge
- Onshore/Offshore cable boundary limits

Drawing 1002_000330-MAE-XX-XX-DR-C-0001 shows the HDD profile for Bacton West. The proposed HDD is approximately 1250m long with an offshore drill depth of approx. 25m to pipe centreline. The maximum depth below the cliff is approx. 55m. It is expected that the offshore cable lay vessel will be able to operate in 9m of water at the exit location.

Drawing 1002_000330-MAE-XX-XX-DR-C-0003 shows the HDD profile for Weybourne West. The HDD is approximately 1180m long and it is expected that the offshore cable lay vessel will be able to operate in 8.8m of water at the exit location.

If the offshore cable laying vessel cannot operate in the depths of water stated, then the profiles may need to be revised to suit the vessel draft.

Calculations have been undertaken to determine the loads required to launch the cable duct from the stringing site across the beach to the sea and to determine the anticipated pull loads to assist with the selection of the HDD equipment.

The calculated launch and installation loads for each option are presented in the table 6.1

In preparing the calculations the following assumptions have been made:

- The pipeline will be launched empty and flooded with seawater prior to temporary wet storage and installation into the HDD bore.
- The duration of the launch and installation into the drilled bore will exceed 1 hour therefore the maximum permissible pull load has been limited to 35% of the cable duct yield strength in accordance with Pipelife Technical Catalogue for Submarine Installation of Polyethylene Pipes, December 2002.

The installation pull loads are calculated at the pull head to determine the maximum anticipated load transmitted through the cable duct and to ensure the maximum permissible load is not exceeded by the drill rig. The total load at the rig, which includes the load required to pull the drill pipe in addition to the cable duct is also presented in Table 6.1 This load is used to help determine the minimum drilling rig capacity. In all cases a 5-tonne holdback load has been included.

Launch and Installation Loads		
Calculation	***Bacton West***	***Weybourne West***
Maximum Permissible Pull Load (t)	107	107
Initial Installation Load at Pulling Head (t)	5.4	5.3
Initial Installation Load at Drilling Rig (t)	19.7	18.9
Final Installation Load at Pulling Head (t)	23.5	22.4
Final Installation Load at Drilling Rig (t)	23.5	22.4

Table 6.1 Launch and Installation Loads.

Based on the data in Table 6.1 the anticipated launch and installation loads for both the Bacton and Weybourne locations are within acceptable limits of the duct mechanical properties.

The required drilling rig capacity is not dependent on the installation loads and will be dependent on the contractor's selected drilling methodology, the final profile length and the ground conditions identified during the scheme specific ground investigation.

It is anticipated at both locations a minimum rig capacity of 250 tonnes may be required. These recommendations are based on the rotary torque capacity due to the need to rotate relatively large diameter tools to form the required 1016mm bore size.

6.2 HDD Flush Volumes

Each HDD location has a positive elevation difference from the entry to the exit location. This results in a differential head of drilling fluid in the bore and during punch out operations to the seabed a volume of bentonite will be discharged.

The elevation difference at each location is:

- Bacton West - 32m
- Weybourne West - 8m

The anticipated flush volumes have been summarised in table 4.5 below and are based on a final ream size of 40" (1016mm) and an HDD entry angle of 15°.

Anticipated Flush Volumes	
Location	*(Flush Volume m^3)*
Bacton - West	100
Weybourne - West	25

Table 6.2 Summary of Anticipated Flush Volumes.

6.3 HDD Flush Mitigation Measures

Mitigation measures have been considered to contain/reduce the volume of drilling fluid released onto the seabed during punch out operations, these are discussed below:

- Use of environmentally friendly drilling fluid (Pure Bore) –Bentonite based fluid could be used to ream the bore to its final size approx. 20-50m from the exit location. Once this is achieved and environmentally fluid such as Pure Bore could be used for the remainder of the punch out distance. Pure-Bore is a naturally biodegradable specially produced, dry, free flowing polymer-based drilling fluid suitable for use in a wide range of drilling applications. Pure-Bore is (CEFAS) registered for use in offshore drilling applications exceeding the highest environmental standards for discharge to sea. Pure-Bore is not a contaminant due to the environmental standards it exceeds.
- It is recommended a volume of Purebore 1.5 times greater than the anticipated flush volume should be pumped downhole before the pilot assembly punches out onto the seabed, this should reduce the amount of Bentonite leaving the borehole with the majority being Pure bore. It is anticipated approx. 10m^3 of Pure Bore should be pumped through the drill string before it reaches the drill bit. The anticipated quantities of Pure Bore volumes for each location is shown below

    - Bacton West - 100m3 x 1.5 + 10m^3 = 160m^3
    - Weybourne West - 25m^3 x 1.5 + 10m^3 = 47.5m^3

  It is recommended that Pure Bore is mixed at a 3k-7kg per m^3 ratio.

- Use of a 40ft container acting as a silt screen to contain the drilling fluid prior to removal – an open top/bottom 40ft container will be installed at the punch out location to contain any bentonite. Hoses could be lowered into the containment area to pump out the bentonite into a skip on a support vessel. A second support vessel may be required for storage of the bentonite, this will need to be analysed further should this method of containment be adopted.

- A casing could be installed at the entry location. The casing length will be determined by the ground conditions at the entry location. When the bore has been reamed to its final stage and punch out operations are due to commence onto the seabed the casing could be drained to the entry pit. This will reduce the amount of drilling fluid released to the seabed by reducing the static head in the bore.

6.4 HDD Water Supply

A quantity of water will be required for the onshore HDD works 24 hours a day 7 days a week. Water source options are presented below:

- Local Water Resource - Local water supplier Anglican Water could be contacted for the use of a local standpipe or hydrant. If the standpipe or hydrant is used, then a meter will need to be fitted and water volumes monitored.
- Water Tanker - Water can be transported to site using water tankers provided by a local company. The HDD site could have water storage containers that would need to be filled by the tankers.
- Seawater - Seawater could be used for the location at Weybourne but the elevation difference at Bacton would be a challenge. The seawater would need to be tested and likely need to be tested to ensure the ensure chemical properties of the drilling fluid are not compromised

7.0 Equipment Requirements

7.1 Rig Site Equipment (Onshore)

An area of around 2500m^2 is typically required as a 'rig site' for the HDD rig and associated equipment. The site could be in any configuration providing the minimum width is at least 15m.

The area outlined for the rig site for this project will require a degree of levelling prior to use. Where possible and if the underlying soils permit, a cut fill operation should be undertaken where the ground is lowered in some areas and the excavated material is re-used to raise the level in the adjacent area creating a level working platform. Should the underlying soils be unsuitable for use as a fill material, consideration would need to be given to the importing of suitable hardcore as a temporary measure to facilitate site construction.

A typical rig site layout is shown below in Figure 7.1A.

It may also be acceptable to create a benched site where two adjacent level areas are constructed, and stone used to form the required surfacing for the working area.

Depending on the final profile design it may be prudent to lower the site around the drill entry points to increase the amount of cover to the cable duct.

Further survey works will be required during the detailed design phases to fully determine the quantity of site preparation works required.

A typical HDD rig site layout is shown below in Figure 7.1A.

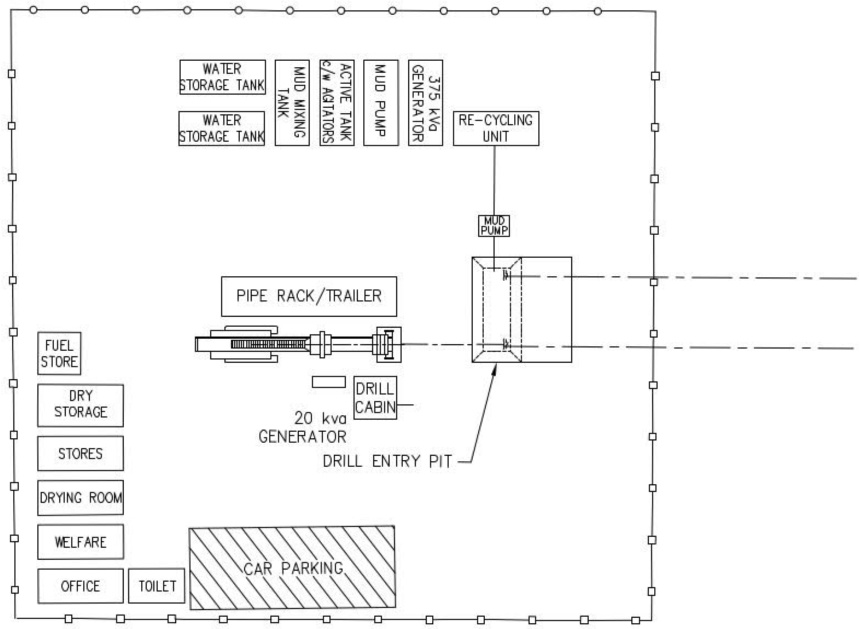


Fig 7.1A. Typical HDD rig site layout.

The main items of plant and equipment required on the HDD rig site are listed below:

- Drilling Rig
- Drill Cabin
- Pipe Rack c/w Drill pipe
- Mud Pump
- Drilling Fluid Active Tank
- Drilling Fluid Mixing Tank
- Drilling Fluid Recycling Plant
- Water Storage Tanks
- Stores container
- 375kVA & 20kVa Generators
- Drilling Fluid Re-Circulation Pump
- Hydraulic Excavator

7.2 Marine Spread Requirements (Offshore)

Depending on the preference of the selected drilling contractor, the HDD support vessel could comprise an anchored barge, spud leg or jack up vessel. The primary duties of the vessel are to support the drilling operations during the final punch-out on to the seabed, duct installation and temporary protection of the PE duct prior to export cable installation.

An anchored vessel would need a minimum of a 4-point anchor system and would need to be supported by an anchor handling vessel. A spud leg barge would need spuds long enough for the maximum anticipated water depth. A jack up would need legs of a sufficient length to allow the vessel to be jacked sufficiently clear of the highest water level.

Spud leg barges are less common but depending on the current speed, current direction and wave height at the site the use of a spud leg vessel may not be possible as the use of this type of vessel in high currents can be problematic. Self-propelled spud leg vessels are available negating the need for an attendant tug. Where vessels are self-propelled, messing and welfare facilities are generally provided. For vessels which are not self-propelled, a tug capable of anchor handling is not normally required. As with flat topped barges spud leg vessels require equipping with all necessary equipment.

Jack-up vessels are more difficult to obtain and generally require booking early to ensure availability. Such vessels can remain on station in the widest range of weather conditions providing adequate freeboard can be maintained. As for other vessel types, Jack-ups require equipping with all the equipment required for the operations to be undertaken. The additional height required from the seabed to the deck of a jack up can be problematic for the recovery of the punch-out assembly to the deck of the vessel and the cable duct would have to be lifted higher out of the water for work on the deck

Flat topped barges are readily available and require equipping with all necessary equipment required for the operation to be undertaken and due to this they can be quite versatile. Depending on the anchor pattern, flat topped vessels can move around on anchors should this be necessary to accommodate the required operations. If required, the anchor pattern can be designed to accommodate a restricted area, such as the existing Sheringham Shoal cables, by varying the anchor size and anchor wire catenary length. An attendant tug is required to tow the barge to the site location and for the positioning of anchors. Positioning of heavy anchors in shallow water could be problematic.

A typical barge layout is presented in figure 7.2A

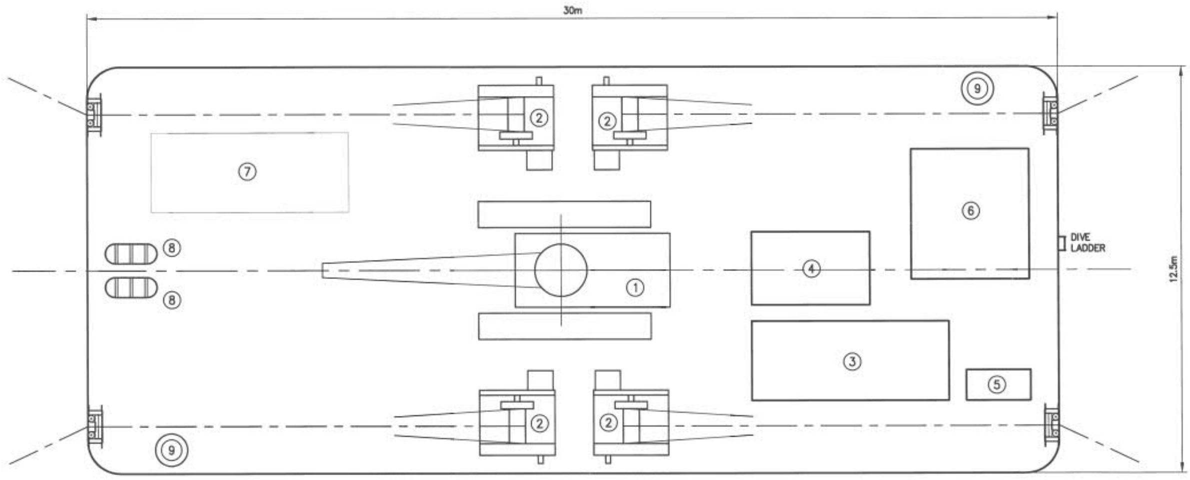


Fig 7.2A. Typical flat top barge layout.

The main items of marine support plant and equipment required for the HDD works will depend on the contractor but may include:

- Flat Topped Barge
- Support Tug
- 4 Point Mooring System c/w Mooring Winches, Anchor Wires and Anchors (Item 2)
- 60 Te Crawler Crane (Item 1)
- Crew Transfer Vessel
- Dive Spread (Item 6)
- Welfare Facilities (Item 4)
- Messing Facilities (Item 3)
- Fuel Tank
- Generator (Item 5)
- HDD Make-up / Break-Out Vice. (Item 7)
- Lift Raft (Item 8)
- Light Towers (Item 9)
- Containment for drilling fluid release

- Pumping system and hoses for drilling fluid recovery

A separate barge with suitably sizes skips would be required to store the volume of bentonite recovered from the containment.

8.0 Interface Works

During all phases of the construction works it is crucial that all parties involved are aware of the daily tasks planned for the day and the approved communication procedures.

Communication with the drill rig and the offshore vessels shall be via a 2-way radio on a pre-agreed channel, if at any time communications are lost then the works will stop immediately.

Roles and Responsibilities of all key personnel should be defined before any works commence and circulated to all involved parties.

For the works involving the HDD and installation of the ducts the following personnel will be involved and will need to agree on an approved communication plan:

- HDD Contractor
- Marine Support Spread
- Client and all other relevant parties.

For the works involving the Cable installation the following personnel will be involved and will need to agree on an approved communication plan:

- HDD Contractor
- Marine Support Spread
- Cable Laying Vessel
- Client and all other relevant parties.

Daily meetings between all parties shall be adhered to, to report on current progress, any concerns for the planned activities and to ensure that all personnel are aware of the daily activities so that the works can be completed in a safe manner.

9.0 Pipe Delivery, Storage & Stringing

9.1 Duct Preparation, Storage and Delivery

The required cable duct could be delivered to site by the following methods:

- By sea in a continuous length (Marine)
- On road in 6 or 12m pipe lengths (Land)

9.1.1 Marine Delivery and Storage

For delivery by sea the supplier would need early contact to confirm the maximum single length of pipe that can be delivered. It is not recommended to butt fusion weld two shorter strings together to form a single long length as the internal bead formed during the welding process cannot be removed and this may not be acceptable for the intended duty.

If the cable duct was delivered to site by sea, a sheltered mooring area would be required to safely store the pipe in the short term until required for installation. It is assumed that cable ducts for each of the two HDDs would be delivered together.

The storage area could be within a local harbour, an area of sheltered water or anchored directly offshore at the proposed landfall location.

All operations to handle and move the cable ducts would require marine support; as a minimum a tow and trail tug would be required.

Minimal work would be required to prepare each duct for installation into the HDD bore. The tow and trail heads would need to be removed and replaced with a pulling head on the lead end and a blank flange on the trail end. A messenger wire would also need to be installed into the duct prior to installation but this could be done in conjunction with flooding the pipeline before it is pulled downhole.

9.1.2 Land Based Delivery and Storage

Delivery of pipe to the landfall location would be undertaken using conventional road transporters. Delivery of the pipe in 12m lengths would be preferred over 6m pipe lengths to reduce the number of loads and welding required to form the final string lengths.

A laydown and stringing site would be required for the fabrication of the pipes at least equal to the proposed HDD length.

Each of the cable ducts would need to be butt-fusion welded to form a single string. It is understood from previous projects that the removal of the internal bead formed during the welding process may be critical to prevent the development of hot spots once the export cable is installed and operational. Methods would need to be developed to confirm full removal of the internal bead during the welding process.

The completed cable ducts would need to be individually launched as required for installation into the drilled bore. It is assumed that the ducts can be launched into the sea directly from the proposed stringing site as was done on the Dudgeon landfall project. Should a remote stringing site be required, a key factor to consider during the selection process is the requirement for launch of the ducts into the water.

The handover of the cable duct from onshore to offshore would need to be carefully managed during the launch process.

As described for the marine method, a pulling head would be required on the lead end of the duct and a blank flange on the trail end with suitable buoyancy. A system for flooding the pipeline before it is pulled downhole will also be required. This system should include the provision for installing a messenger wire inside the duct for the later cable installation.

9.2 Stringing Location - Bacton

The proposed stringing location for the Bacton West HDD landfall option is situated along the beach front at Bacton terminal.

North Norfolk District Council worked with Bacton Gas Terminal Owners (Shell and Perenco) to develop a sand scaping scheme to protect the gas infrastructure and extend the life of the sea defences at Bacton and Walcott.

The sand scaping scheme placed 1.8million cubic metres of sand on the beach to enhance the natural protection of the cliffs and beach from the erosive power of the sea. The scheme was completed during the summer of 2019 and the footprint of the works is shown below in figure 9.2A.

Fig 9.2A. Footprint of the sandscpaping works undertaken at Bacton.

The sand scaping works has created an opportunity for the stringing location at Bacton to be fabricated into one length on the beach ready for installation offshore. The beach levels have been raised an additional 2-3m along the footprint shown above. Access to the beach would be via a slip road running parallel with the Bacton terminal, Figures 9.2B and 9.2C below shows the access road to the beach and the raised level of the beach due to the sand scaping works.

Fig 9.2B Access to the beach.

Fig 9.2C. Beach levels following sandscrapping.

A working area of approx. 1350m x 15m would be sufficient to fabricate the ducts into single lengths ready for installation.

Permissions would need to be granted from Natural England under the Marine Management Organisation (MMO) licence to construct the duct on the beach and also from Bacton terminal for use of the access road leading to the beach for pipe deliveries and plant/equipment.

Drawing Number 1002_000330-MAE-XX-XX-DR-C-0007_P01_S3 in Appendix D shows the red boundary for the stringing site and the HDD rig site.

9.3 Stringing Location - Weybourne

The proposed stringing location at the Weybourne West HDD landfall location falls within the boundaries of The Muckleburgh Military Collection Museum and the Weybourne Atmospheric Observatory and runs along the perimeter fencing. The location of the stringing area is shown in figure 9.3A below:

Fig 9.3A. Proposed stringing location at Weybourne.

The ducts could be fabricated into single lengths along the route proposed above and launched offshore via an access road to the beach from the field. Figures 9.3B and 9.3C show the stringing location along the perimeter fence and the slip which could be used for launching the ducts ready for installation.

Fig 9.3B Stringing area along perimeter fence.

Fig 9.2C. Access from field to beach for launch.

A working area of approx. 1250m x 15m would be sufficient to fabricate the ducts into single lengths ready for installation.

The proposed location was previously used for stringing the duct for the Dudgeon landfall cable ducts, reinforcing the feasibility to string pipe in this area.

Permissions would need to be granted from Natural England under the Marine Management Organisation (MMO) licence to launch the duct across the beach to the sea and also from the Muckleburgh Military Collection Museum and Weybourne Atmospheric Observatory for use of the land for stringing operations.

Drawing Number 1002_000330-MAE-XX-XX-DR-C-0009_P01_S3 in Appendix D shows the red boundary for the stringing site and the HDD rig site.

10.0 Joint Bay Location

A single jointing pit is proposed for the transition joints for both offshore cables at each landfall location.

The proposed location of the onshore cable jointing bay for Bacton is shown on drawing 1002_000330-MAE-XX-XX-DR-C-0007_P01_S3 in Appendix D.

Subject to detailed design the jointing pit would need to be approximately 10m x 6.5m and situated landward of the HDD entry point.

The proposed location of the onshore cable jointing bay for Weybourne is shown on drawing 1002_000330-MAE-XX-XX-DR-C-0009_P01_S3 in Appendix D.

Subject to detailed design the jointing pit would need to be approximately 10m x 6.5m and situated landward of the HDD entry point.

The location of the jointing pit at Weybourne has been selected adjacent to the jointing bay for the Sheringham Shoal and the Dudgeon windfarm cables in order to minimise the area of land that becomes sterile once construction is complete. The joint bay location is approx. 67m from the Dudgeon landfall joint bay and 91m from the Sheringham Shoal cable joint bay.

It is anticipated two offshore cables would enter the offshore side of the joint bay where they will be split into six cables, three cables for each circuit. The cables would exit the onshore side of the joint bay for the continuation on the onshore route. The general arrangement of the joint bay is shown below in Figure 10.0A.

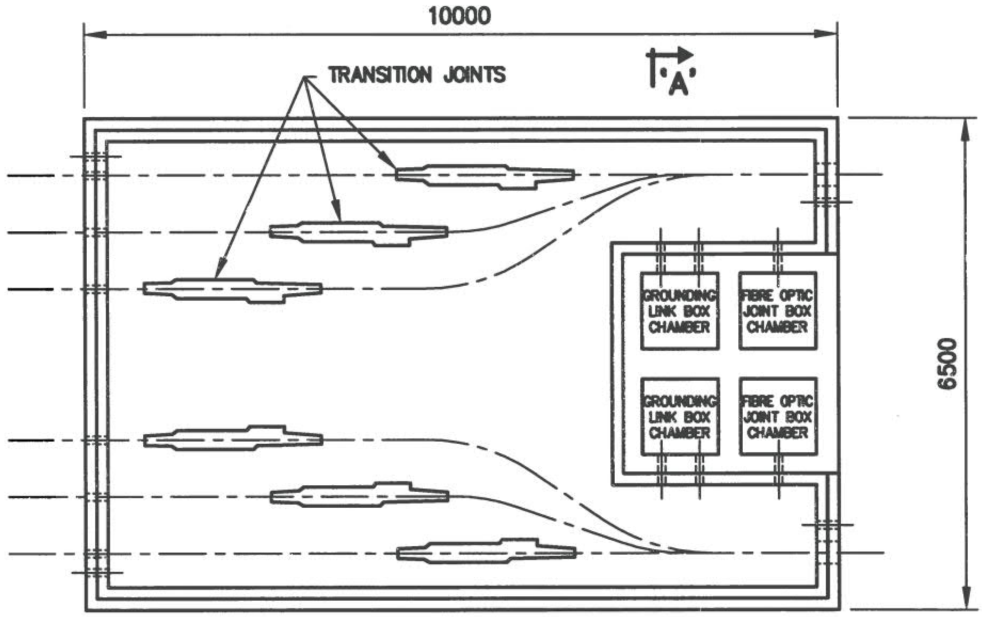


Fig 10.0A. General joint bay arrangement.

11.0 Seabed Works

11.1 Seabed Preparation - Pre-Duct Installation

In advance of the HDD works, a survey of the seabed around the area of the HDD exit location would be required to determine the seabed features and bathymetry. This survey would provide the information required to determine the level of seabed preparations required.

The area around the proposed HDD exit location would need to be cleared of any debris and if required be generally level. Any further seabed preparations would be dependent on the ground conditions identified around the drill exit point during the scheme specific ground investigation.

Should boulders been encountered around the proposed exit location then they will need to be removed prior to duct pulling operations. The boulders could be moved onto the deck of the support vessel or offline of the exit location using either a wire cargo net or an orange peel grab fitted to the crane on the support vessel. Figures 11.1A and 11.1B show the wire cargo net and orange peel grab.

Fig 11.1A. Wire Cargo Net.

Fig 11.1B Orange Peel Grab.

11.2 Seabed Works – Cable Duct Installation & Protection Measures

Once the cable duct has been installed into the HDD bore a messenger wire will be installed into the duct and tied off to the flange on the duct end. The duct will need a smooth transition onto the seabed to ensure the cable integrity is maintained. The transition profile should be accurately determined during detailed design.

Figure 11.2A below shows the position of the duct after HDD pulling operations.

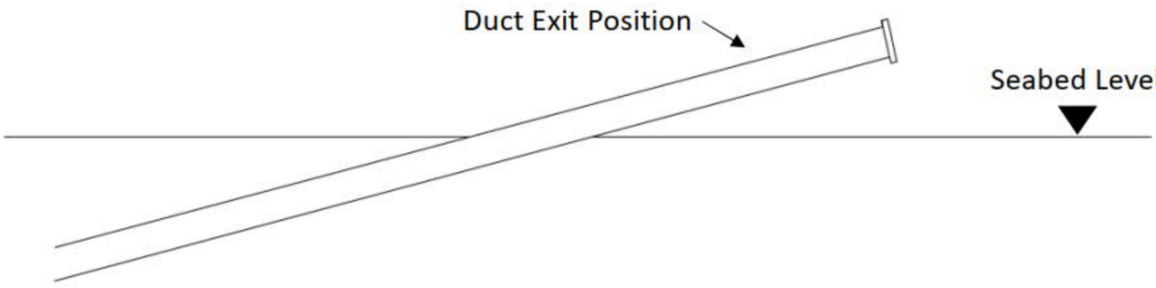


Fig 11.2A. Position of duct after HDD pulling operations.

Figure 11.2B below shows the duct excavated to the required depth of cover. The transition will ensure that the duct is not overstressed.

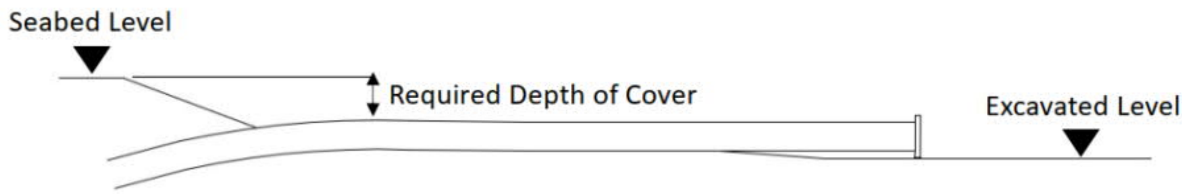


Fig 11.2B. Final position of duct.

The transition could be formed by pre-excavating a trench around the proposed HDD exit point prior to the completion of drilling or by locally lowering each duct once installation is completed. Pre-excavating a trench in advance of HDD punch-out carries the risk of the trench not being excavated in the correct location.

Post installation lowering involves working around the installed duct. Further investigation should be undertaken following the results of the scheme specific ground investigation once the seabed conditions are known. Consideration should also be given to the environmental / ecological impact of excavating on the seabed.

If the seabed sediments are suitable dredge pumps could be used to form the transition of the duct onto the seabed. The Toyo pump would need to be lowered to the required depth. This unit will macerate and fluidise the seabed using 4” to 6” semi rigid hoses excavate a trench to the required depth. A Typical dredge pump is shown in Figure 11.2C.

Fig 11.2C. Dredge Pump.

Once the transition profile has been excavated then mattresses will be lowered onto the duct to push it down onto the seabed and protect it. The duct end will be buoyed off to ensure it can be easily located for the cable installation.

Temporary protection measures could include:

- Concrete mattresses / rock bags / concrete collars over the portion of the cable duct remaining on the seabed to provide stability in the anticipated sea conditions. The level of protection required will need to be determined during detailed design when data on the anticipated currents will be available. Figures 11.2D and 11.2E shows the lifting of a concrete mattress from a support vessel and the concrete mattresses submerged protecting an offshore duct.

Fig 11.2D Concetre matress being lifted from vessel.

Fig 11.2E Concrete matresses covering submerged duct.

11.3 Seabed Works – Cable Installation into Duct

Prior to cable installation, the temporary protection would need to be recovered and the ducts exposed. It is envisaged that some further excavation may be necessary due to sediment transfer that may have taken place in the interim period.

Once the cable is ready to be installed and the duct is excavated to the required depth the following offshore construction activities can commence:

- Remove the blank flange,
- Trench the seabed to the required depth and to a location agreed with the cable laying vessel for the handover of the messenger wire,
- Run the messenger wire to the cable laying vessel to connect to the pulling head on the cable,
- The messenger wire will be pulled into the pre-excavated trench,
- Pulling operations can commence once all parties have established good lines of communication,

- Once the cable is pulled through the duct the cable laying vessel can commence offshore works to the windfarm,
- The cable and duct can then be backfilled from the HDD exit location to the handover location,
- The as-built survey can then be performed,
- The marine spread is then de-mobilised.

The final methodology should be developed by the cable manufacturer in conjunction with the offshore cable installation contractor taking the vessels, materials and burial equipment into consideration.

11.4 Seabed Works - Post Cable Installation

After the cable is installed and the cable laying vessel is laying the cable offshore, post cable installation seabed works will commence.

The duct ends will need to be fitted with a split blank flange to provide a seal and prevent sediment entering the duct. A typical split blank flange sketch is shown below in Figure 11.4.

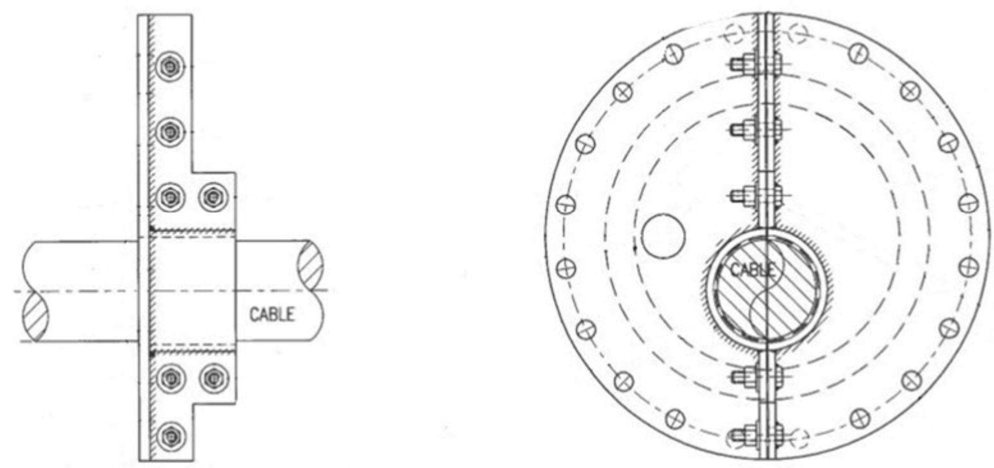


Fig 11.4. Typical split flange sketch.

Once the blank flange is bolted to the duct and the cable is laid in the trench, the trench and duct can be backfilled. Consideration should be given to ballasting the duct to ensure it remains on the trench bottom.

Once backfilling operations have been completed a survey can be performed to ensure all parties are satisfied with the reinstatement of the seabed before the support vessel is de-mobilised.

12.0 Conclusion & Recommendations

12.1 Conclusions

Based on the available information, it is considered that the installation of the cable landfalls are feasible using HDD techniques at both the Bacton and Weybourne.

Following a screening exercise the most favourable landfall locations are Bacton West and Weybourne West.

The available ground conditions appear suitable for the application of HDD, however further scheme specific ground investigation will be required to confirm the ground conditions and the feasibility of the proposed HDD profiles. Following further ground investigation, potentially the depth of cover may be reduced to suit the cable system design without increasing the risk of break out.

The results of any scheme specific ground investigation will also support the calculations that determine the maximum length of casing pipe that could be installed at the rig site.

Both HDD locations have been designed to exit in depths of approx. 9m of water, it has been assumed that the cable laying vessel can operate in these water depths.

A cable duct specification of 710mm OD SDR11 PE100 HPPE suitable to accept 275mm diameter offshore cable is proposed. The cable duct delivery and stringing options have been included within this report for both locations. At Weybourne it is preferred to string the pipe along the perimeter fence of the Muckleburgh Military Collection Museum and at Bacton it is preferred to string the pipe along the upper beach outside the terminal.

A general layout and position for the joint bay for each HDD location has been included within the report. The Weybourne joint bay location is proposed to be in close proximity to the Sheringham Shoal joint bay and Dudgeon joint bay to minimise the sterilised area covered by the cable corridor once construction is complete. A single joint bay for both offshore cables is proposed. In plan the proposed joint bay is 10.0m x 6.5m with four access hatches, one for each cable. The joint bay is approx. 67m from the Dudgeon joint bay and 91m from the Sheringham Shoal joint bay.

It is proposed the Bacton joint bay be positioned in the field as shown in the drawings in Appendix D. The land is relatively flat with access from Bacton Road to the field perimeter.

The requirement for determining the level of seabed preparation has been included and will require further development once the results of the scheme specific ground investigation and detailed profile design are available. Temporary protection measures for the offshore section of the cable duct remaining on the seabed prior to installation of the export cable are also included and will need further development as more met ocean data becomes available.

A cost estimate has been developed for each preferred landfall. These are included in Appendix B

A common outline programme has been developed for both preferred landfalls given the similarity of the anticipated ground conditions and HDD profiles. An outline programme is included in Appendix C.

12.2 Recommendations

Further ground investigation should be undertaken both offshore and onshore to ensure the proposed HDD profile is drilled within a competent formation and the risk of breakout is minimal. A breakout offshore could have environmental impacts, delays to the project and increased costs. Further ground investigation is also required to assist the HDD contractor with tool selection for the anticipated ground conditions. It is recommended that geotechnical engineers with specific HDD knowledge are engaged to supervise any proposed ground investigation works to ensure the correct level of information is obtained.

It is recommended topography and bathymetry surveys are conducted along the cable corridor to ensure accurate HDD profiles can be developed at detailed design stage.

The HDD profile should be re-assessed once further ground investigation has been completed and the results reported. As part of this reassessment it is recommended that a hydro-fracture analysis be

performed to determine the minimum allowable profile depth that can be achieved. It is understood that the cable system design would benefit from a shallow profile depth, hence why this should be investigated further.
It is recommended initial cable system design checks are performed against the preferred HDD profiles to confirm their feasibility from a cable design perspective before continuing with further detailed design.

A successful HDD will be dependent a number of factors. Primarily a competent contractor suitably experienced to undertake the work should be appointed. Further detailed design should be undertaken once additional ground investigation results are available. The profile design should be supported by a detailed HDD procedure and risk assessment with contingency measures incorporated.

Consideration be given to installing a casing at the HDD entry location onshore for both locations, this would prevent a potential ground collapse in any unfavourable ground formation. Further engineering should be carried out to determine the length of casing that could be successfully driven into the ground formation at the HDD rig site.

Early discussions should be held with landowners and Natural England regarding stringing of the pipe in the proposed areas.

The final duct transition profile should be developed by the cable system designer and HDD designer in a collaborative manner to ensure the permanent profile does not compromise the integrity of the duct or cable.

The temporary protection measures to the offshore end of the cable duct post installation should be given careful consideration and be further developed once met ocean conditions are known. Engineering associated with temporary stability of the ballast should be conducted.

If the duct annulus remains empty it is recommended to undertake permanent works engineering over the expected lifetime of the cable taking into account thermal heat dissipation during operation. The ducts will be subject to external pressure from the surrounding soil and combined with heat from the cables they may creep and deform over a period of time so their integrity needs to be assessed over the design life of the cable.

A suitable source of water should be established at an early stage for mixing of the drilling fluid.

13.0 Alternative Trenchless Techniques

If further alternative trenchless techniques require investigation as part of further study work then it is recommended direct pipe installation (DPI) be considered.

This method combines the advantages of micro tunnelling and HDD technology. In one step only, a prefabricated pipeline can be installed, and the required borehole excavated at the same time. Some advantages of DPI are listed below:

- Greatly reduces the possibility of hydraulic fracture and inadvertent returns.
- Able to operate in all geologies from sand and silt to gravel, cobbles and hard rock.
- Single Pass borehole is excavated, and product pipeline installed at the same time. No reaming and no pullback.
- Steerable both vertically and horizontally. Capable of managing both uphill and downhill slopes as well as curved drives along the alignment.
- Requires access from only one side. Ideal for water outfalls and sensitive environmental areas.
- Small footprint – ideal for densely populated or congested industrial settings.
- Lower manpower and equipment requirements.
- Able to launch from surface, a shallow pit or deep shaft.
- Capable of a much shorter and shallower crossing profile, thereby requiring less pipe.
- Fully closed slurry circuit which uses up to 70% less bentonite. The mud system cleans and reuses the bentonite –thereby greatly decreasing disposal costs.

NOTE- If DPI is to be considered the duct would need to be steel and not HPPE in order to withstand the compressive force from the pipe thruster.

Appendix A – Typical HDD Method Statement

EXTENSION OF THE DUDGEON AND SHERINGHAM SHOAL OFFSHORE WIND FARMS

HORIZONTAL DIRECTIONAL DRILLING METHOD STATEMENT

Produced for:

EQUINOR

Document No.

Revision: P01

Date: 28th February 2020

J Murphy and Sons Ltd
1 Bridge Court
Stonecross Business Park
Golborne
Wigan
WA3 3JD

Record of Issue

Revision	Description	Originator	Reviewed	Approved
01	Issued for Review	SB	MP	JC

Record of Change

Page No	Description of Change

Hold

Page No.	Hold item

CONTENTS

1.0 Introduction

1.1 General

The project involves the installation of cable duct landfalls at a location to be determined on the North Norfolk coast at either Weybourne or Bacton for the proposed Dudgeon offshore windfarm. Two separate offshore cables are required to make landfall, each cable is required to be installed within a separate cable duct installed by Horizontal Directional Drilling (HDD).

This procedure covers the installation of the two cable duct landfalls by HDD and includes the required activities as part of the planning, design and construction of the landfall along with the general purpose Health, Safety and Environmental constraints which apply to all persons entering, travelling or working on the site.

The proposed offshore cable is 204mm in diameter; the proposed HDD duct is 710mm OD, SDR11, HPPE pipe.

1.2 Programme

The programme for the works is dependent on the Clients programme for the works and the availability of the HDD rig and marine support equipment.

Set up of the drilling rig and associated equipment will be undertaken over 12 hr shifts 7 days per week; pilot hole, reaming, hole cleaning and pipeline pullback will be executed on a 24hr basis in two 12hr shifts 7 days per week.

2.0 Health and Safety

Prior to commencing work, all personnel including subcontractor's personnel shall attend any required inductions before being allowed to enter site. The induction will outline the safe working practices that must be adhered to at all times. Personnel will also be informed at this time of any relevant environmental issues and any safety equipment that they will require. All visitors to site shall also attend a shortened visitor's induction which will include all relevant information and the safety equipment that is required.

All personnel working on site have an up to date relevant CSCS/CPCS card.

Appropriate PPE will be worn by all personnel on site suitable for the tasks to be carried out. As a minimum this will include:

- Hard hat,
- Safety Glasses
- Fire Resistant Overalls
- Safety Boots
- Hi-Vis long sleeve top

Gloves and Ear Protection will be available for use as required.

Life vests will be worn by offshore personnel.

All works will be carried out in a safe manner, using only certified equipment, and the work site maintained so that it functions safely and efficiently.

At the start of every shift a safety walk around will be conducted and any actions noted will be immediately rectified and the remediation measures discussed in the toolbox talk for the day's work activities. No productive work will be undertaken until all actions have been rectified.

The drill entry pit and equipment will be inspected on a daily basis and the condition of the excavation noted in the daily work report. No man access will be permitted into the launch pits.

Any recommendations or corrective actions highlighted by the JMS Health and Safety Advisor and / or the Site Health and Safety Supervisor shall be corrected immediately as instructed.

A health and safety risk assessment is included in Appendix A.

3.0 Preparations for drilling

3.1 Known Services

All known services will be identified by others and the records made available to the drilling contractor prior to the commencement of the drilling works. Prior to any excavation being undertaken within the site, CAT scanners or similar devices will be used to determine the presence of underground services. Exposure of any service will be undertaken in accordance with HSG47.

The location of services will be checked and confirmed by all parties and be stated in the permit to dig and drill. No excavations or drilling will commence until a permit has been issued by JMS, detailing the depth to the service and the depth of crossing beneath service.

The location of the Sheringham Shoal cables and jointing pit will be marked out on site prior to equipment mobilisation. The jointing pit will be fenced to prevent equipment and personnel access.

3.2 Site Preparation

The working area for the drill site will be prepared in advance of equipment mobilisation. The area will be levelled, using a cut fill operation if required and a suitable hardstanding created for placement of the HDD equipment.

The front anchor for the drill rig, required to resist the installation pushing / pulling forces will be constructed in accordance with the temporary works design calculations and drawings.

Equipment will be delivered to the site along the route detailed in the project Traffic Management Plan and positioned on site in accordance with the rig site layout drawing

JMS will ensure that a clearly defined route is established between the site entrance and the working area; this will be communicated to all vehicle drivers upon entry to the site. All vehicle movements will be controlled by a banksman who will direct all wagons to the correct location within the compound for off loading.

In advance of the commencement of drilling operations a drill entry pit approximately 4.0m x 5.0m x 1.2m deep will be excavated to collect drilling fluid returning to the surface. The pit sides will be battered back as necessary.

All pits will be fenced to prevent access and suitable warning signs displayed.

Submersible pumps will be installed in the pit to allow the returned drilling fluid to be re-cycled into the drilling fluid cleaning and mixing system. Water ingress into the launch pit during construction will be controlled by sump pumping. Water removed from excavations will be pumped into the drilling fluid mixing system.

All ground works on the entry side will be undertaken with a hydraulic excavator.

Once the drilling equipment has been established if required, noise deflection screens will be erected around noise generating equipment.

3.3 Casing Pipe Installation

Should the scheme specific ground investigation indicate that a casing pipe is required to support the near surface superficial deposits a 50” diameter steel casing pipe will be installed from the drill entry point over the required length.

3.4 Bottom Hole Assembly

The Bottom Hole Assembly (BHA) comprises the elements required to control and record the direction of the pilot bore. The BHA for the completion of the drill will be as depicted in figure 1 below.

Figure 1 – Typical Bottom Hole Assembly.

1. 10⅞" Polycrystalline diamond compact bit
2. Cross over sub
3. 6¾" 3 stage mud motor
4. 6¾" Shock tool
5. Gyro Steering tool
6. Drill pipe

The BHA will be made up on the drill rig and all connections tightened to the torque specified by the manufactures. Once the BHA is complete it will be removed from the rig and laid on the ground on 'v' blocks and a roll test calibration performed.

Upon completion of the calibration the BHA will be replaced on to the rig, surface tests on the gyro signal will be undertaken prior to commencing operation of the gyro by setting the tool to seek north.

Once all calibration and surface checks are completed pilot hole drilling will commence.

The gyro steering tool is connected to the surface by a wireline running from the back of the steering tool through the drill pipe to the steering engineers' computer.

3.5 Drilling Fluid

During the hole drilling process drilling fluid is used. The most important functions of the drilling fluid are:

- Loosening the soil in front of the bit
- Providing power to the drill bit via the mud motor
- Lubrication of the drill string and BHA
- Removal of soil particles out of the hole
- Keeping the soil parts in suspension
- Stabilisation of borehole wall

The proposed drilling fluid for the majority of the project will comprise Ultrabore, an ultra high yield, 200-mesh sodium bentonite drilling fluid specially formulated to improve borehole stability, optimise hole cleaning and maintain borehole integrity in horizontal drilling applications mixed with potable water to achieve the required fluid properties for the ground conditions being drilled through with the addition of varying amounts of Drill-Slip depending on the ground conditions being drilled through. If required additional additives will be available on site to enhance the carrying capacity of the fluid to remove cuttings from the drilled hole and to prevent bit balling halting progress.

Ultra bore is a bentonite based fluid which is thixotropic in nature. The bentonite (montmorillonite) clay particles become fully hydrated in the mixing water are platelet shaped giving the fluid the ability to form a filter cake along the edges of the bore. As the platelets build up on the bore wall an effective seal is developed to prevent fluid loss into the formation.

During drilling operations where punch-out on to the seabed is required and during the initial stages of pullback when drilling fluid escapes through the offshore end of the bore Pure-Bore drilling fluid will be used. Pure-Bore is a naturally biodegradable specially produced, dry, free flowing polymer based drilling fluid suitable for use in a wide range of drilling applications as an additive to bentonite based fluids and for short lengths as a single sack product.

Pure-Bore is CEFAS registered for use in offshore drilling applications exceeding the highest environmental standards for discharge to sea. Pure-Bore is not a contaminant due to the environmental standards it exceeds.

Water for fluid mixing will be provided to site by tanker.

The fluid that returns to the surface at rig side will be recycled during drilling operations (treated with shale-shakers, de sanders and de silters) in order to keep the raw material consumption and disposal volumes as low as possible.

The fluid properties will be regularly monitored to ensure the fluid design is appropriate for the ground conditions being drilled through. The specific gravity of the fluid will be recorded, as it is pumped downhole, as it returns to the surface and after cleaning to ensure that the drill cuttings are being removed from the bore and removed from the fluid before re-circulating.

Drilling fluid returns will be monitored to determine if fluid is being lost. If significant quantities of fluid are being lost or fluid circulation is lost, drilling operations will be halted while checks for breakout are undertaken. If breakout is not occurring the drill string will be retracted to clear any downhole blockages and regain fluid returns back to the drilling rig.

The cuttings which have been separated from the fluid will be collected in skips; if required the cuttings will be mixed with a propriety solidifying additive to solidify the material for disposal offsite.

3.6 Drilling Fluid Breakout Monitoring / Mitigation

During drilling activities, the downhole fluid pressures will be continuously monitored to ensure the downhole pressure does not exceed the anticipated overburden pressure at any point along the drilled profile. Any sudden losses in downhole pressure will be investigated as a potential break-out.

Regular walkovers will be undertaken to check for visible leakage of drilling fluid along the line of the drilled profile.

If a large bentonite breakout does occur drilling operations will be stopped, and the Environmental Advisor and Emergency Crew contacted. Initial actions, where possible, will be to contain the flow of drilling fluid using a combination of materials including straw bales, sedimatts and teram.

Once the initial actions to contain the flow of drilling fluid have been undertaken an assessment of the potential causes and remediation measures will be established.

Possible control measures will include:

- Pumping of a loss control additive to seal the area of breakout
- Grouting of the bore and re-drilling

Once the area of breakout has been sealed drilling operations will continue.

4.0 Pilot Hole Drilling operations

4.1 Pilot Hole

The pilot hole will be drilled to achieve the designed HDD profile.

Power to the drill bit is provided by the mud motor which is powered by the flow of drilling fluid through the motor, the pilot hole is advanced as the drill rig pushes drill pipe into the ground. In addition to the power provided to the drill bit the drilling fluid exiting at the drill head fluidises the surrounding soil forming a void for the drill string to be advanced in to. The drilling fluid also suspends the soil particles in the fluid for carrying out of the bore.

Steering of the pilot hole is undertaken by the steering engineer who instructs the driller to perform any required steering corrections to maintain the designed profile. The direction of the pilot hole is maintained by controlling the high side of the BHA. Where no profile corrections are required a drill rod can be rotary drilled where steering corrections are required the BHA is advanced without rotation allowing the bend in the BHA to alter the direction of the drill bit.

Once each drill pipe is steered along the profile the drill string and BHA will be rotated and the full joint of drill pipe pulled back and re-advanced back along the bore. This is undertaken to ensure all of the drill cuttings are suspended in the drilling fluid for removal from the hole.

A survey reading of the gyro location is taken as a minimum at the end of each drill pipe and the details logged on to the pilot hole record sheet. Once the survey is complete and the details checked the drill string will be broken and another drill pipe added on the rig. The wireline connection is broken and remade as every joint of drill pipe is added.

The procedure for breaking and remaking the wireline connection is as follows:

- The drill pipe tool joint will be broken, unscrewed and the wireline cut leaving sufficient spare to make the next connection;
- Drill pipe with the wireline pre-installed will be moved on to the rig floor;
- The wireline connections are made using a metal wire crimp, with a cable shrink sleeve (sealed with the application of a hot air blower) the joint is then tape wrapped;
- A hand pull test and visual inspection is undertaken on each wireline connection to check the joint is sealed.
- Once the wireline connection is complete the drill pipe tool joint will be fastened and torqued up allowing drilling operations to re-commence.
-

Approximately every 2 hours the drilling operations will be temporarily halted to allow the gyro steering tool to recalibrate to north.

Pilot hole operations will continue until a point approximately 20m short of the proposed drill exit point where the pilot hole will be halted. Final punch out onto the beach will not be undertaken until the hole has been enlarged to the required final diameter. This is undertaken to prevent drilling fluid escaping onto the seabed during reaming and cleaning operations, this method also minimises the duration the marine spread is required to on station.

Once the pilot hole is halted and the final survey reading undertaken the BHA will be completely removed from the drilled hole. As each joint of drill pipe is removed from the bore drilling fluid will be pumped to ensure all remaining cuttings stay in suspension for removal from the bore during reaming operations. As the drill pipe is removed the wireline will be disconnected and removed from inside the drill pipe. Upon reaching the drill rig the BHA will be dismantled and stored for the second drill or demobilised from site. After the BHA is removed the hole will be enlarged using forward reaming.

5.0 Reaming and Hole Cleaning operations

5.1 Reaming Operations

Reaming operations will be undertaken to enlarge the bore to a diameter suitable to accept the cable duct. It is anticipated that the bores will be enlarged to approximately 30 to 40% larger than the cable duct being installed.

To minimise the drilling fluid escaping onto the beach, forward reaming has been adopted. Forward reaming involves pushing and rotating reamers from the rig to a position short of the proposed exit point until the bore reaches a suitable diameter to accept the cable duct. Only once the bore has been enlarged to the required diameter and a cleaning run undertaken, to confirm the bore is free of drilled cuttings, will punch-out onto the seabed occur.

The first push reamer will be added to the drill string at the onshore drilling rig and reaming operations will commence as the rig pushes and rotates the reamer along the line of the pilot bore, a bull nose and hole centraliser will be located ahead of the reamer to ensure the reamer follows the path of the pilot hole.

The proposed reaming schedule is presented in the following table, the size, diameter and order of the reaming passes may be adjusted depending on the ground conditions encountered during drilling operations.

Pass Number	Diameter (inch)
Reaming Pass 1	18
Reaming Pass 2	24
Reaming Pass 3	32
Reaming Pass 4	40
Cleaning Run	40

Table 1 Proposed reaming schedule.

During reaming operations, the drilling fluid flow rate and the speed of drilling will be carefully controlled to ensure all of the drill cuttings and debris is suspended within the drill fluid and removed from the bore.

Drilling fluid returning to the surface through the annulus of the hole will be cleaned, re-conditioned and re-used downhole.

Each reaming operation will be halted approximately 30-50m short of the drill exit location at the end of the pilot bore to prevent drilling fluid escaping on to the seabed, the number and length of drill pipes added will be monitored to ensure the bore is halted at the correct location; as a secondary check a significant increase in push pressure at the drill rig will indicate the location of the end of the pilot bore.

Once a borehole of 40" has been reamed short of the punch out location the reaming of the 30-50m "plug" offshore will commence. The pilot assembly will drill the plug from onshore and the assembly will be retrieved to the bed of the support vessel. The pilot hole assembly will be broken down and the 18" reaming assembly will be connected. The 18" reamer will then be reamed from the support vessel until it reaches the 40" bore, it will then be pushed back out of the bore and to the bed of the support vessel ready to break down. This process will be repeated for the 24", 32" and 40" ream until the full bore reaches a size of 40". The bore will then be ready for hole cleaning operations.

The crane from the support vessel will be required to retrieve and lower the downhole tooling to the bore.

5.2 Hole Cleaning

Hole cleaning operations are undertaken to ensure that the bore is free of drilled cuttings prior to punch-out on the seabed and the cable duct installation.

Ahead of the reamer for the cleaning run will be the final punch-out assembly, the punch-out assembly will also ensure the reamer remains central in the drilled bore.

If any problem areas are noted during the cleaning run a second cleaning run may be undertaken. Final punch-out on to the seabed will not commence until the drilled hole is deemed to be clean and free of cuttings.

6.0 Cable Duct Installation Operations

6.1 Punch-out on to the Seabed

During the final ream the marine spread will be positioned close to the HDD alignment and seawards of the HDD exit point to await punch-out on to the seabed. Any required seabed preparation will have been previously undertaken.

As the punch-out assembly approaches the end of the bore the drilling fluid will be changed to Pure-Bore. The punch-out assembly will be advanced along the planned profile through the undisturbed ground until punch-out on the seabed occurs; punch-out onto the seabed will be detected by a sudden loss in face pressure.

Once punch out is detected at the drilling rig, divers, from the marine spread will be mobilised to confirm the punch-out location. Once the drill head is located a buoy will be attached to the drill head to facilitate later recovery.

Once the punch-out location is confirmed, the remainder of the punch-out assembly will be advanced out of the bore monitored by divers. As soon as the entire assembly is visible on the seabed all rotation will be halted and the drill string dead pushed out of the hole.

Divers will connect the drill string to the crane on the work vessel to facilitate recovery of the punch-out assembly and drill string to the deck of the vessel.

Removal of the punch-out assembly will be undertaken on the deck of the work vessel using a scorpion break out tool in combination with the onshore drill rig which provides the rotation required to unscrew the joint. When fully removed from the drill string the entire punch-out assembly and reamer will be stored on the deck of the work vessel.

6.2 Preparations for Pullback

Generally, HPPE flooded on seawater will have neutral buoyancy. In order to prevent wave action forcing the duct down to the seabed buoyancy will be required. A nominal uplift of 20kg/m will ensure the duct can be installed in a controlled manner. Typical offshore buoyancy aids are show in Figures 6.2A and 6.2B.

Fig 6.2A. Gael Force Trawl Float.

Fig 6.2B. Polyform Net Buoy.

The buoyancy aids can be strapped to the duct and once each buoyancy aid reaches the transition point from the sea to the exit location a diver can cut the straps and release the buoyancy aids. The crane on the support vessel will hold the duct at the transition location using a cradle, this will enable the crane to position the duct to ensure the overbend transition does not over stress the duct. Three support vessels will be required during the pulling operations. The first support vessel will be at the exit location with the crane holding the pipe in place, the second will be positioned approx. hallway way along the duct and will keep the duct in a straight line during the installation and the third vessel will be connected to the back of the duct providing a nominal 5t holdback force during the pull.

To allow the cable duct installation to commence the drill string needs to be connected to the pulling assembly. The pulling assembly comprising a swivel, universal joint and barrel reamer will have been mobilised with the support vessel. Once the punch-out assembly has been removed from the drill string the pulling assembly will be connected on the deck of the work vessel with support from the drilling rig and the breakout / make up tool.

The pulling assembly will then be connected to the pulling head at the front of the cable duct. The cable duct will be aligned along the side of the support vessel and the pulling head lifted on to the deck and aligned with the pulling assembly. The final pin connection will be made between the pulling assembly and the cable duct allowing the pullback operation to commence.

6.3 Pullback Operation

Pullback will be coordinated between the Marine Superintendent and the onshore HDD Superintendent.

To commence the pull back operation the drill string and pulling assembly will be lowered to the seabed; the weight of the pulling assembly will negate the buoyant nature of the flooded cable duct.

Once the drill string, pulling assembly and the lead end of the cable duct is on the seabed the pulling operation can commence.

The cable duct will be pulled by the drilling rig, as drill pipes are pulled and removed at the rig the cable duct is advanced through the drilled hole. This procedure is repeated until the pulling head appears in the drill entry pit at the drill rig site.

At all times during the pullback operation a nominal 5 tonne holdback will be maintained on the trail end of the cable duct.

During the pullback operation some drilling fluid will inevitably escape from the bore around the exit point. This cannot be avoided as the cable duct displaces the drilling fluid as it enters the HDD bore.

For reference it should be noted that the Pure-Bore drilling fluid is environmentally friendly, is also biodegradable, is not a contaminant and does not contribute to suspended solids in the marine environment.

6.4 Pigging Operations/Messenger Wire

Once the duct has been installed it will need to be pigged to confirm it has not deformed during installation and a messenger wire installed for the cable pull at a later date.

A foam gauge pig will be inserted into the onshore pipe end and a 10mm galvanised messenger wire will be threaded through a hole in a new blind flange, the blind flange is then bolted to the stub flange on the end of the sleeve pipe.

An onshore water pump will be mobilised to the HDD rig site. The suction hose will be connected to a storage tank and the delivery hose will be connected to the branch connection on the blind flange.

At the offshore end of the sleeve pipe the flange will be removed and a cargo net fixed to the duct end to capture the pig on its arrival.

The shore side pump will be activated to propel the gauge pig along the sleeve pipe and into the cargo net. As the gauge pig moves along the 710mm sleeve pipe it will pull the 10mm galvanised messenger wire into the sleeve pipe.

On arrival of the gauge pig into the cargo net, the barge will advise the HDD rig site to stop the pump.

An additional 20-30m of wire will be pulled through the sleeve pipe from the offshore end using the winch on board the support vessel. An additional 5-10m will be allowed for at the rig site before the wire is cut and terminated on the pad eyes welded to the inside face of the blind flanges. The flanges are then bolted to the pipe ends to close off the sleeve pipe.

7.0 Site Clearance

7.1 De-Rigging Site

Once the cable duct is installed in the bore the rig and auxiliary equipment will be re-positioned to undertake the second HDD. On completion of the second HDD the equipment will be de-rigged, loaded and transported offsite.

8.0 Personnel, Plant and Equipment

LABOUR (per shift)

- 1 No. HDD Shift Supervisor / driller
- 1 No. Steering Engineer (Pilot Hole only)
- 2 No. Drilling Operatives
- 1 No. Mud Engineer
- 1 No. Fitter
- 1 No. Electrician
- 1 No Excavator operator

PLANT (major items)

- Drilling rig
- Drill Cabin
- Pipe Rack c/w Drill pipe
- Mud Pump
- Drilling fluid active tank
- Drilling Fluid mixing tank
- Drilling Fluid recycling plant
- Water storage tanks
- Store container
- 375kVA & 20kVa Generators
- Drilling fluid re-circulation pump
- Hydraulic excavator
- Radio(s)

9.0 Emergency Arrangements

Emergency service contact numbers will be posted in the site office. All site emergencies will be reported to the JMS Health and Safety Manager.

Site First Aiders are identified on notice boards and will be notified during the JMS site induction.

The nearest hospital with A&E facilities will be determined in advance of the works and the location of this hospital and shortest route will be displayed on site notice boards.

10.0 Drill Records

During the pilot hole drilling all relevant steering data such as inclination, azimuth, torque and drilling fluid pressure are recorded on the drill log sheet. For easy reference the position of the drill head is also indicated on the plan/profile drawing and will be plotted onto an As-Built drawing after all works are completed.

All relevant drilling parameters such as push/pull forces, torque, drilling fluid pressure and pump rate are recorded as well on to the drill log sheet. Drill fluid parameters such as specific gravity, viscosity, sand content and mud weight are also measured and recorded on the drilling fluid data sheet. Typical record sheets are included in Appendix C.

11.0 HDD Support Marine Spread

The marine spread required to support the HDD operations will be mobilised from a port located close to the site location.

All necessary equipment will be mobilised to the port and positioned / sea fastened to the deck.

The marine spread will only be mobilised to the location of the site once support operations are required.

12.0 Cable Duct Stringing and Launch

The cable duct will be delivered to site in 12m lengths and butt fusion welded into a complete string using the firing line technique along the proposed cable duct stringing site. Once the duct is complete the pulling head for installation into the drilled bore will be installed on the lead end of the string and a domed end installed on the trail end.

Each of the two cable ducts will be launched separately as required by the progress of the HDD works.

To launch the cable duct, initially the entire string will be pulled using an excavator until the pulling head is on the beach. A messenger wire will be brought ashore from the launch tug / support vessel. The messenger wire will be pulled until the launch wire is received on the beach. The launch wire will be connected to the pulling head on the pipeline.

The cable duct will be launched as the launch tug / support vessel moves offshore towing the duct behind. During the launch a nominal holdback tension of around 5 tonne will be maintained on the tail of the cable duct.

Once the end of the pipeline reaches the beach the trail rigging will be handed to the offshore vessel which will take control of the cable duct.

Once fully offshore the cable duct will be flooded with seawater to reduce the buoyancy as it is pulled downhole, The duct will then be towed to the HDD exit location and aligned ready for installation.

APPENDIX A – HEALTH AND SAFETY ASSESSMENT

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
1	Unloading and removal of equipment at site	Failure of lifting equipment. Load slippage or load dropped.	Injuries or fatalities to personnel	X			Lifting plan to be produced under the supervision of a qualified appointed person for lifting operations. All lifting equipment will be checked prior to start of works. Certification for the lifting equipment must be valid. The lifting equipment operator shall carry out daily checks to ensure the equipment is fit for purpose. Radius chart to be with the lifting equipment. The operator must fully understand charts and SWL Qualified slinger/ signallers shall control lifting operations. Only qualified personnel will operate lifting equipment.			X	
2	Positioning the lifting equipment	Lifting equipment tip over, Unstable ground, Impact with other items of plant and equipment, Trapping.	Crushing injuries or fatalities to personnel, plant damage	X			The lifting equipment will have a banksman present at all times during travel on site. The banksman will be fully conversant with good signalling practice. The ground stability must be assessed prior to any lifting.			X	LOLER CPCS trained slinger / signaller

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
							Clear access must be given to the lifting equipment when moving around the works area. Clearance of not less than 600mm should be maintained between any part of the crane and any obstacle. Traffic control measures where required.				
3	Rigging and slinging	Failure of lifting equipment, Impact with swinging load, load exceeds SWL	Injuries or fatalities to personnel	X			All lifting equipment to be visually inspected prior to any lifting. All slings and chains will be of correct rating. Lifting equipment operator will not undertake any lift that will take him out of safe working radius. All lifts will be correctly balanced prior to lift. Safe lifting practice to be used at all times. Sharp edges to be suitably packed to prevent chaffing of slings.			X	PUWER Lift Plan written by Appointed Person
4	Lifting a load	Load falling	Personnel impact from by falling load Injuries or fatalities to personnel	X			All loads will be lifted using the correct rigging methods. Tag lines are to be used on lifts where required. Loads lifted to the minimum height necessary to clear obstacles. No personnel are to be allowed to stand under a suspended load. A banksman is to be used at all times			X	

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
							Only qualified personnel will operate lifting equipment.				
5	Positioning the load	Injury caused by trapping fingers or hands, Overloading of landing areas.	Limb injuries Electrocution – death, burns	X			All personnel will be instructed in safe lifting practices. The lifting equipment will be under the control of a banksman at all times. The landing position will have been assessed prior to the load being landed. The banksman will ensure that the lifting equipment does not encroach into any power line exclusion zones identified by goal posts and signs.			X	Lift Plan in place
6	Working at height	Falls from height	Injuries or fatalities to personnel	X			Safe means of access to the working area to be provided. Ensure all equipment offloaded using bottom lifting eyes to prevent personnel accessing trailers. Where bottom eyes are not present equipment to be delivered to site pre-slung. Ensure handrails are in place on equipment where access is required.			X	Work at Height Regulations 2005
7	Excavation of Mud Pit	Collapse of excavation. Underground services	Injuries or fatalities to personnel	X			No personnel to enter in to any excavation that is unsafe, Batter, stepped or supported is a requirement. All excavations are to be fenced and signed to prevent unauthorised entry. Hearing protection to be issued to all personnel when required			X	

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
							CAT scan to be carried out prior to excavation. All underground services to be identified as per HSG47				
8	Tool up for drilling activities	Injury caused by manual handling. Slips, trips and falls	Injuries or fatalities to personnel. Electrocution – burns, death Heat exhaustion		X		Use mechanical handling were possible All electrical equipment to be inspected and tagged prior to use. Area to be kept clear of all debris A supply of good water to be available at all times All spillages to be contained and spill kits to be available at all times			X	
9	Drilling fluid mixing	Skin contact with drilling fluid, Manual Handling, Working at height Dust	Chemical burns, Injuries or fatalities to personnel Dust Inhalation		X		COSHH sheets to issued and the correct PPE to be worn, only biodegradable fluids to be used Use mechanical handling where ever possible Correct working platforms to be installed at all times. Dust masks to be used.			X	
10	Drilling operations	Noise Dust Entanglement / impact with rotary equipment.	Injuries or fatalities to personnel		X		Hearing protection to be issued to all personnel when required and worn in designated areas Dust suppression to be employed when required. Emergency stop buttons to be fitted in accessible positions			X	

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
							All hoses to be secured, gauges to be inspected prior to use. Only experienced and competent operators to be used (CPCS Trained). Correct guarding to be in place at all times. Lock out /Tag out & Permit to Work to be used for all maintenance operations Spill kits to be available at all times. Two way communications to be in place for lone workers. No persons to be allowed to stand in close proximity to the moving drill string.				
11	Drilling fluid breakout	Slipping or skidding Access to beach	Injuries to personnel		X		Monitor drilling pressures and return flows at all times to control overpressure Small breakouts to be controlled by temporary sumps and sand bags/earth banks. Larger breakout or breakout into watercourse / beach will be controlled. Re-engineer drilling fluid			X	
12	Concreting	Skin contact with concrete Slips, trips & falls	Chemical burns Injuries to personnel			X	Use PPE namely gloves and goggles. Operatives to keep skin covered during placement operation			X	
13	Drilling Operations	Loss of drill tools downhole	Blockage in bore. Potential loss of bore requiring re-		X		Monitor rotary pressure on drill rig to ensure pressures are maintained below the level where breakage of drill pipe may occur.			X	

No	Activity	Hazard	Harm	Pre control risk assessment			Control	Post control risk assessment			References regulations, procedures, method statements
				H	M	L		H	M	L	
			drill along new profile. Loss of downhole tooling				Identify supplier and location of suitable 'fishing tools' prior to start of project to recover equipment lost downhole.				
14	Cable Duct Pullback	Bore Failure prior to pullback	Increase in programme duration. Loss of bore.		X		Monitor drill fluid returns to ensure all material cut is removed from the bore. Undertake further cleaning runs until bore deemed acceptable for pullback. Re-engineer drilling fluid			X	
15	Cable Duct Pullback	Stuck Cable Duct	Loss of bore and cable duct		X		Ensure bore is clean prior to pullback commencing. Pull cable duct out of bore seaward using marine spread. Undertake further cleaning runs until bore deemed acceptable for pullback.			X	
16	Drill rig operation	Failure of drill rig during pullback	Loss of bore. Cable duct stuck in bore Increase in programme		X		Monitor drill fluid returns to ensure all material cut is removed from the bore. Ensure drill rig is fully maintained to prevent breakdown occurring. Have spare parts available for repair.			X	

Appendix B – ENVIRONMENTAL RISK ASSESSMENT

Any recommendations or corrective actions highlighted by the JMS or Client Environmental Advisors will be actioned immediately.

All site personnel will attend an environmental induction prior to working on site.

Site personnel shall ensure that:

- The site is left clean and tidy at all times.
- Nesting birds are not disturbed, and their presence reported immediately to JMS Environmental Advisor.
- There will no pumping of any fluid into any watercourse; pumping is expected to be carried out to remove waste drill fluids and contaminated fluids into tanks for disposal off site.
- Spills and leaks are reported immediately to the Project Manager and cleaned up promptly.
- Re-fuelling on the HDD rig site to be carried out as far away as practicable from any drain or watercourse. When re-fuelling drip trays will be used, spill kits will be available for use, if required.
- Waste will be segregated prior to disposal.
- All gates, when not in use, are shut.
- Any complaints raised, should be directed through to the JMS Project Manager

An Environmental Impact Assessment for the works covered by this procedure follows:

No.	Activity	Hazard	Possible Consequences	Pre Risk Assessment			Control Measures	Post Risk Assessment			References
				H	M	L		H	M	L	Regulations / Procedure / Method Statement
1	Work in ecologically sensitive areas.	Generation of noise, fumes, ground compaction and disturbance	Damage to flora and fauna Permanent damage to site integrity Landscape / visual impact Species exclusion from their habitat	X			Following Method Statement and direction of JMS Environmental Team			X	Town and Country Planning Act 1990 Wildlife and Countryside Act 1981 Environment Act 1995 The Habitat and Species Regulations 2010
2	Vehicle and plant operations	Emission of noxious gases Dust	Excessive emissions to the atmosphere Environmental degradation Dust hazardous to human health and to the environment	X			Frequent vehicle and plant maintenance Vehicle ignitions to be turned off when not in use Ensure banksman in place for all reversing operations Damping down dust during dry conditions			X	Clean Air Act 1993 Environmental Protection Act 1990 Pollution Prevention and Control (England and Wales) Regulations 2000
3	Vehicle and Plant operations - Working in proximity to trees and hedgerows	Lack of care when working near trees	Damage to trees and hedgerows Disturbance of wildlife	X			Careful operations near trees and hedgerows No working under canopy of trees Establish a root protection area			X	The Town and Country Planning (Trees) Regulations 1999 The Hedgerow Regulations 1997 Wildlife and Countryside Act 1981
4	Vehicle and plant operations	Emission of noise	Disturbance to public and livestock Complaints from public and landowners		X		Frequent vehicle and plant maintenance Noise mitigation methods employed as required			X	Control of Pollution Act (CoPA) 1974 The Noise Emissions in the Environment for use

No.	Activity	Hazard	Possible Consequences	Pre Risk Assessment H	Pre Risk Assessment M	Pre Risk Assessment L	Control Measures	Post Risk Assessment H	Post Risk Assessment M	Post Risk Assessment L	References: Regulations / Procedure / Method Statement
							Noise monitoring.				Outdoors Regulations 2001 The Control of Noise (Codes of Practice for Construction and Open Sites) (England) Order 2002
5	Vehicles and plant operations	Spills and leaks	Groundwater and contamination from toxic substances	X			All vehicles to carry adequate spill kits. Frequent vehicle and plant maintenance Standing plant to have drip trays which are to be kept empty			X	Environmental Protection Act 1990 COSHH Regulations 2002
6	Refuelling and vehicle maintenance	Spills and leaks	Contamination to ground and water courses	X			Refuelling to occur above plant nappies or drip tray. Sufficient spill kit to be available on site, particularly at sensitive locations All fuel bowsers to carry adequate spill kit and granules, and funnels. Refuelling not to take place within 10m of any water course or drain. 30m is preferable.			X	Control of Pollution (Oil Storage) Regulation 2001
7	Construction work impact on local communities.	Increased noise, traffic, dust, mud, light and working hours Excessive disturbance to local communities and dwellings in proximity	Complaints from the local communities and dwellings in proximity		X		Observe traffic management plan. Dust management Implement noise mitigation measures, if required Observe agreed working hours if practicable			X	New Roads & Streetworks Act 1991 Control of Pollution Act (CoPA) 1974 Town and Country Planning Act 1990

No.	Activity	Hazard	Possible Consequences	Pre Risk Assessment			Control Measures	Post Risk Assessment			References: Regulations / Procedure / Method Statement
				H	M	L		H	M	L	
8	Drilling Fluid Control	Breakout during drilling operations and pullback	Potential contamination of marine environment. Visual impact of surface breakout. Potential contamination of ground and / or seawater Potential damage to fish		X		Drilling fluid controlled at drill site, any breakout detected by drop in pressure. Visual inspection along line of drill by route walkers. Spills to be cleaned up immediately Carry out Emergency Response Procedure.			X	
9	Waste collection. Waste generation.	Waste material left on site.	Uncontrolled waste on site, detrimental to animals, possibly toxic to plants and soil. Failure of duty of care.		X		All waste to be segregated on site. Waste to be taken off site for disposal by licensed carriers to licensed disposal point			X	
10	Production of drilling fluid	Waste Fluid	Excess fluid left on site - detrimental to watercourses / groundwater		X		Waste cleared up and removed from site. Waste to be taken off site for disposal by licensed carriers to licensed disposal point			X	
11	Marine Pollution	Contamination	Danger to sea and wildlife		X		Toolbox talks to inform operatives of offshore procedures Spill kits available on all vessels		X		

Appendix C – RECORD SHEETS

- Pilot Hole Record
- Reaming / Hole Opening Record
- Hole Cleaning Record
- Pipeline Pullback Record
- Drilling Fluid Log Sheets

MURPHY
WORLD-CLASS INFRASTRUCTURE

CONTRACT No.

CLIENT: | PROJECT: | LOCATION:

PILOT HOLE DRILL RECORD

Drill Pipe: Bit Type: Survey System: Measurement Ref: Start Date: Finish Date:

Joint	Time		Pipe Length (m)		Inclination	Azimuth	Push / Pull	Torque	Drilling Fluid			Comments
									Pressure	Viscosity	Flow	
	Start	Finish	Each	Total			psi	psi	psi	secs	l/min	

Signed for JMS: Signed for Client: Date: Page: of

	CONTRACT No.
CLIENT:	PROJECT:	LOCATION:

REAMING / HOLE OPENING RECORD

Reamer Type and Size: Start Date: Finish Date:

Joint	Start	Finish	Elapsed Time	Rotary		Pull		Drilling Fluid			Comments
				GEAR	PSI	GEAR	PSI	Pressure	Viscosity	Flow	

Signed for JMS: Signed for Client: Date: Page: of

		CONTRACT No.
CLIENT:	PROJECT:	LOCATION:

MURPHY
WORLD-CLASS INFRASTRUCTURE

CLEANING RUN RECORD

Reamer Type and Size: Start Date: Finish Date:

Joint	Start	Finish	Elapsed Time	Rotary		Pull		Drilling Fluid			Comments
				GEAR	PSI	GEAR	PSI	Pressure	Viscosity	Flow	

Signed for JMS: Signed for Client: Date: Page: of

MURPHY WORLD-CLASS INFRASTRUCTURE		CONTRACT No.
CLIENT:	PROJECT:	LOCATION:

PIPELINE PULLBACK RECORD

Reamer Type and Size: Start Date: Finish Date:

Joint	Start	Finish	Elapsed Time	Rotary		Pull		Drilling Fluid			Comments
				GEAR	PSI	GEAR	PSI	Pressure	Viscosity	Flow	

Signed for JMS: Signed for Client: Date: Page: of

	DRILLING FLUID LOG SHEET			
Job No (Site)				
Mud Consultant				
Date:			Shift:	
Time	Vis	Density	Ph	Sand Content
Product Consumption				
Product 1	Product 2	Product 3	Product 4	Product 5
Signed JMS:		Date:		

Appendix B – Cost Estimates

EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
WEYBOURNE OPTION
Price Matrix for 2No x 710mm x 1176m PE conduits

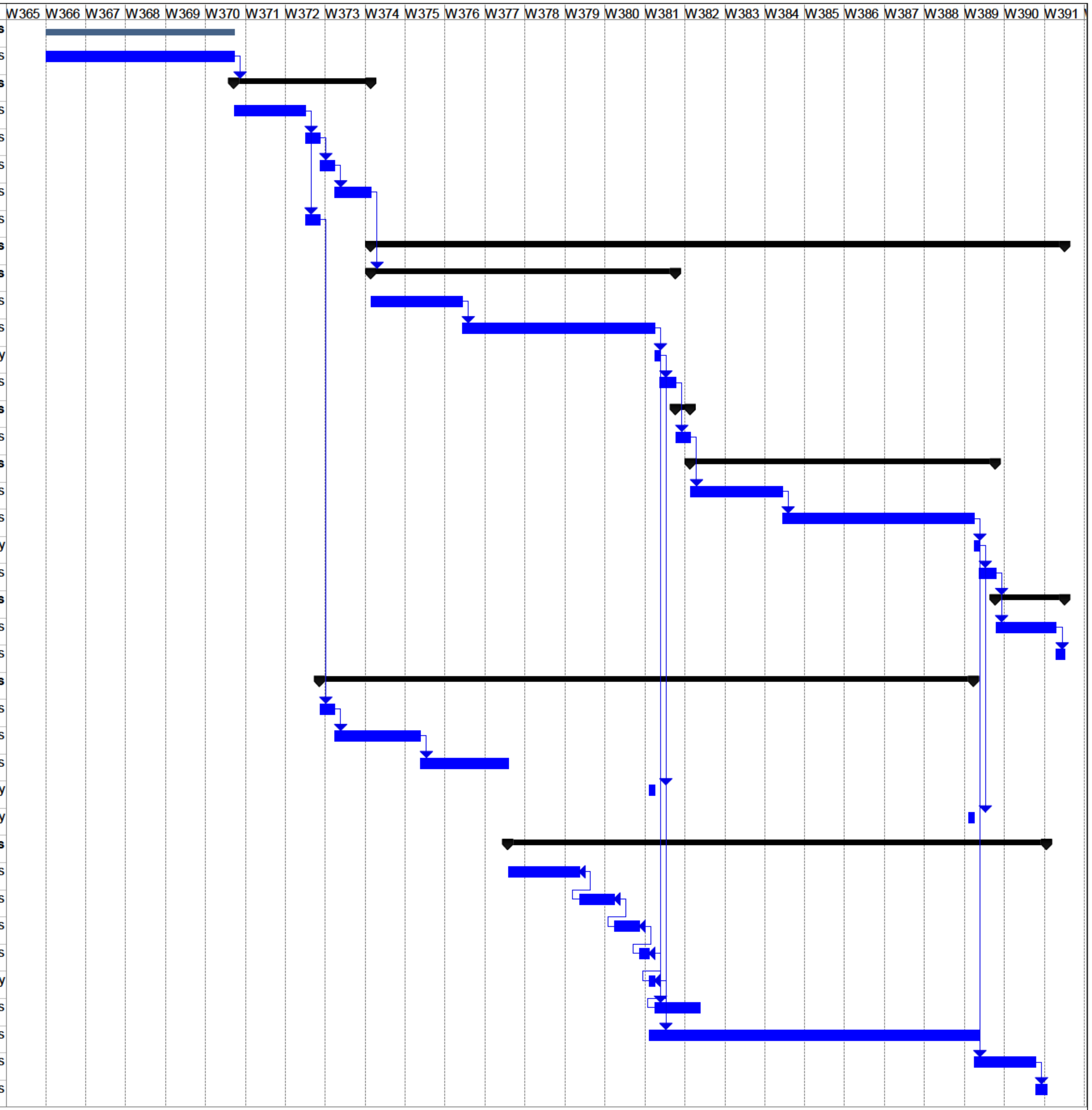
Description of Works	Cost (£)
Project supervision	345,000
Design of HDD profile	20,000
Temporary works design	15,000
Procurement of pipe duct	660,000
Carry out pre works onshore survey	5,000
Mobilisation of HDD spread to site	60,000
Mobilisation of marine support spread	150,000
Demobilisation of HDD spread from site	50,000
Demobilisation of marine support spread	145,000
Preparation of HDD rig area & site compound	70,000
Preparation of pipe stringing area	30,000
Establish site offices & welfare facilities	115,000
Maintain site offices and welfare facilities	30,000
String & weld PE pipe duct	110,000
Installation of pipe by HDD	5,235,000
Offshore support vessels & crew	1,410,000
Reinstate rig site and office compound, Backfill mud pits & water pits, Remove rig site and replace topsoil	15,000
Reinstate pipe stringing site	50,000
Total	8,515,000

EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
BACTON OPTION
Price Matrix for 2No x 710mm x 1239m PE conduits

Description of Works	Cost (£)
Project supervision	345,000
Design of HDD profile	20,000
Temporary works design	15,000
Procurement of pipe duct	695,000
Carry out pre works onshore survey	5,000
Mobilisation of HDD spread to site	60,000
Mobilisation of marine support spread	150,000
Demobilisation of HDD spread from site	50,000
Demobilisation of marine support spread	145,000
Preparation of HDD rig area & site compound	70,000
Preparation of pipe stringing area	30,000
Establish site offices & welfare facilities	110,000
Maintain site offices and welfare facilities	30,000
String & weld PE pipe duct	110,000
Installation of pipe by HDD	5,470,000
Offshore support vessels & crew	1,410,000
Reinstate rig site and office compound, Remove rig site and replace topsoil, Backfill mud pits & water pits	15,000
Reinstate pipe stringing site	50,000
Total	8,780,000

Appendix C – Outline Programme

ID		Task Name	Start	Finish	Duration
1		**Pre-mobilisation Engineering**	**Mon 31/03/14**	**Fri 02/05/14**	**25 days**
2		Engineering and Procedures	Mon 29/03/21	Fri 30/04/21	25 days
3		**Mobilisation & Site Preparation**	**Sat 01/05/21**	**Mon 24/05/21**	**27 days**
4		Preparation of Drill Rig Site	Sat 01/05/21	Thu 13/05/21	14 days
5		Installation of HDD Rig Anchorage	Thu 13/05/21	Sun 16/05/21	3 days
6		Mobilisation of HDD Rig Site Equipment	Sun 16/05/21	Tue 18/05/21	3 days
7		Set-up and Testing of Rig Site Equipment	Tue 18/05/21	Mon 24/05/21	7 days
8		Preparation of Cable Duct Stringing Site	Thu 13/05/21	Sun 16/05/21	3 days
9		**HDD Operations**	**Tue 25/05/21**	**Thu 23/09/21**	**137 days**
10		**Horizontal Directional Drilling (Duct 1)**	**Tue 25/05/21**	**Sat 17/07/21**	**60 days**
11		Pilot Hole	Tue 25/05/21	Wed 09/06/21	18 days
12		Reaming & Hole Cleaning	Thu 10/06/21	Tue 13/07/21	38 days
13		Punchout on to Seabed	Tue 13/07/21	Wed 14/07/21	1 day
14		Cable Duct Installation	Wed 14/07/21	Sat 17/07/21	3 days
15		**Move Rig for Duct 2**	**Sat 17/07/21**	**Mon 19/07/21**	**3 days**
16		Move HDD Rig for Duct 2	Sat 17/07/21	Mon 19/07/21	3 days
17		**Horizontal Directional Drilling (Duct 2)**	**Tue 20/07/21**	**Sat 11/09/21**	**60 days**
18		Pilot Hole	Tue 20/07/21	Wed 04/08/21	18 days
19		Reaming & Hole Cleaning	Thu 05/08/21	Tue 07/09/21	38 days
20		Punchout on to Seabed	Tue 07/09/21	Wed 08/09/21	1 day
21		Cable Duct Installation	Wed 08/09/21	Sat 11/09/21	3 days
22		**Demobilise Rig Site**	**Sat 11/09/21**	**Thu 23/09/21**	**14 days**
23		De-rig Site	Sat 11/09/21	Tue 21/09/21	12 days
24		Demobilise Equipment	Wed 22/09/21	Thu 23/09/21	2 days
25		**Cable Duct Welding & Launch**	**Sun 16/05/21**	**Tue 07/09/21**	**129 days**
26		Pipeline Delivery	Sun 16/05/21	Tue 18/05/21	3 days
27		Welding Operations Duct 1	Tue 18/05/21	Wed 02/06/21	17 days
28		Welding Operations Duct 2	Wed 02/06/21	Thu 17/06/21	17 days
29		Launch Duct 1	Mon 12/07/21	Tue 13/07/21	1 day
30		Launch Duct 2	Mon 06/09/21	Tue 07/09/21	1 day
31		**HDD Support Marine Spread**	**Fri 18/06/21**	**Mon 20/09/21**	**106 days**
32		Mobilise Vessel to Port	Fri 18/06/21	Wed 30/06/21	14 days
33		Mobilise Support Equipment to Vessel	Wed 30/06/21	Tue 06/07/21	7 days
34		Load and Seafasten Equipment	Tue 06/07/21	Sun 11/07/21	5 days
35		Sail to Drill Site Location for Duct 1 Installation	Sun 11/07/21	Mon 12/07/21	2 days
36		Set up at Drill Site Location	Mon 12/07/21	Tue 13/07/21	1 day
37		Support HDD Operations for Duct 1 installation	Tue 13/07/21	Wed 21/07/21	9 days
38		Support Vessel Standby	Mon 12/07/21	Wed 08/09/21	65 days
39		Support HDD Operations for Duct 2 Installation	Tue 07/09/21	Sat 18/09/21	12 days
40		Demobilise Vessel	Sat 18/09/21	Mon 20/09/21	2 days



Programme for Weybourne and Bacton

Legend				
Task	Project Summary	Inactive Summary	Manual Summary	External Milestone
Split	External Tasks	Manual Task	Start-only	Progress
Milestone	External Milestone	Duration-only	Finish-only	Deadline
Summary	Inactive Milestone	Manual Summary Rollup	External Tasks	

Appendix D – Drawings

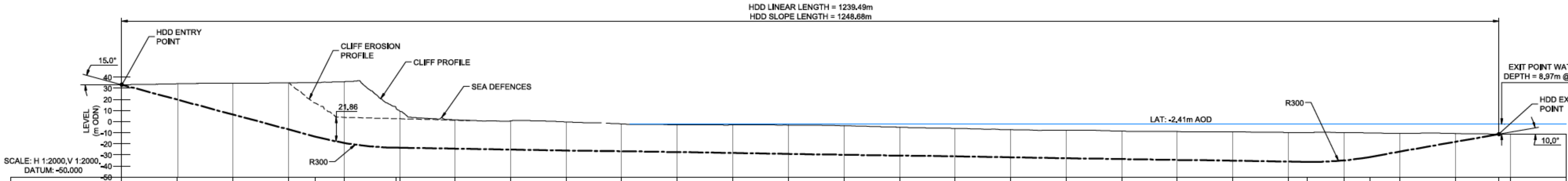
- 1002_000330-MAE-XX-XX-DR-C-0001_P02_S3 - Landfall HDD Profile Bacton West
- 1002_000330-MAE-XX-XX-DR-C-0003_P01_S3 - Landfall HDD Profile Weybourne
- 1002_000330-MAE-XX-XX-DR-C-0006_P01_S3 - Bacton Access Route Reline Boundary
- 1002_000330-MAE-XX-XX-DR-C-0007_P01_S3 - Bacton HDD & Stringing Reline Boundary
- 1002_000330-MAE-XX-XX-DR-C-0008_P01_S3 - Weybourne Access Route Reline Boundary
- 1002_000330-MAE-XX-XX-DR-C-0009_P01_S3 - Weybourne HDD & Stringing Reline Boundary

LEGEND:

- HDD CENTRELINE
- OFFSHORE SCOPE AREA LIMITS
- ONSHORE SCOPE AREA LIMITS
- SEA DEFENCES
- EXISTING GAS PIPELINE
- RECOMMENDED BOREHOLES (BHxx)

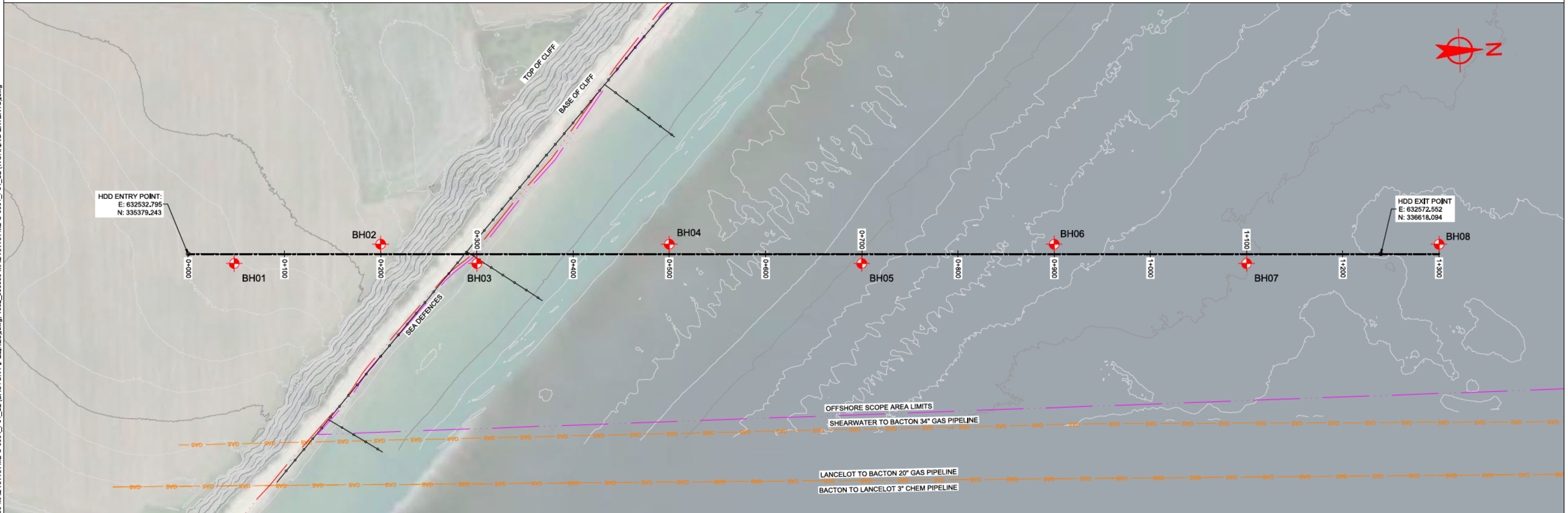
NOTES:

1. ALL DIMENSIONS, LEVELS AND CHAINAGES IN METRES UNLESS OTHERWISE STATED. LEVELS ARE RELATIVE TO O.D. NEWLYN AND CHAINAGES RELATIVE TO ZERO AT HDD ENTRY POINT
2. TOPOGRAPHICAL SUVEY INFORMATION OBTAINED FROM DEFRA DATA SERVICES PLATFORM:
   BATHYMETRY COASTAL MULTIBEAM - 2016
   LIDAR 1M & 2M DTM COMPOSITE - LATEST AVAILABLE DATA
3. GRID CO-ORDINATE SYSTEM OSGB 36
4. THE DETAILS SHOWN ON THI DRAWING ARE FOR STUDY PURPOSES ONLY AND HAVE BEEN PREPARED FROM THE DATA AND INFORMATION AVAILABLE AT THE TIME. DETAILS MAY CHANGE DEPENDING ON THE RESULTS OF FURTHER ENGINEERING AND SURVEYS
5. EXISTING PIPELINE INFORMATION SOURCED FROM OIL & GAS AUTHORITY 'OGA_INFRASTRUCTURE_WGS84'
6. CLIFF EROSION PROFILE BASED ON INFORMATION SOURCED FROM NATIONAL COASTAL EROSION RISK MAPPING (NCERM) 2018-2021
7. RECOMMENDED BOREHOLES TO BE 10M OFFSET FROM PROPOSED HDD ALIGNMENT



GROUND LEVEL	33.15	33.96	34.37	34.83	35.23	35.93	11.66	9.47	1.59	0.57	-0.33	-2.10	-2.82	-2.89	-3.00	-3.76
CENTRE OF PIPE	33.15	19.76	6.36	-7.04	-13.48	-19.22	-23.67	-23.72	-24.49	-25.27	-26.04	-26.82	-27.59	-28.37	-29.14	-29.92
COVER TO CENTRELINE	0.00	14.20	28.02	41.86	48.71	55.14	35.33	33.19	26.08	25.84	25.71	24.71	24.77	25.48	26.14	26.16
CHAINAGE	00.00	50.00	100.00	150.00	174.06	200.00	247.05	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00

GROUND LEVEL	-5.13	-6.14	-7.23	-7.82	-8.62	-9.02	-9.23	-9.79	-9.80	-9.90	-10.20	-10.66	-10.75	-11.38	-11.18	-11.36
CENTRE OF PIPE	-30.69	-31.47	-32.24	-33.02	-33.79	-34.57	-35.34	-36.12	-36.38	-35.03	-31.85	-27.16	-18.34	-11.38		
COVER TO CENTRELINE	25.56	25.32	25.01	25.19	25.17	25.55	26.11	26.32	26.57	25.13	21.65	16.49	7.59	0.00		
CHAINAGE	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1050.00	1066.62	1100.00	1123.37	1150.00	1200.00	1239.49	1250.00	1300.00



MURPHY WORLD-CLASS INFRASTRUCTURE

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

0 50 100 1:2000 200m

This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P03	M.ANDERSON	S.BYRNE	J.CURRAN	25/02/20	RECOMMENDED BOREHOLE LOCATIONS ADDED
P02	M.ANDERSON	S.BYRNE	J.CURRAN	21/02/20	PROFILE AMENDED TO 20m+ UNDER CLIFF AND 25m UNDER SEA BED
P01	M.ANDERSON	S.BYRNE	J.CURRAN	13/02/20	FOR REVIEW & COMMENT

Project:	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision: P03	Dwg Title: LANDFALL HDD PROFILE BACTON WEST - OPTION 1
Suitability: S3	
Scale @ A1: 1:2000	Dwg No: 1002_000330-MAE-XX-XX-DR-C-0001
Sheets: 1 OF 1	Purpose of Issue: REVIEW & COMMENT
Internal Proj.Ref: 1002_000330	Client Ref Number: -

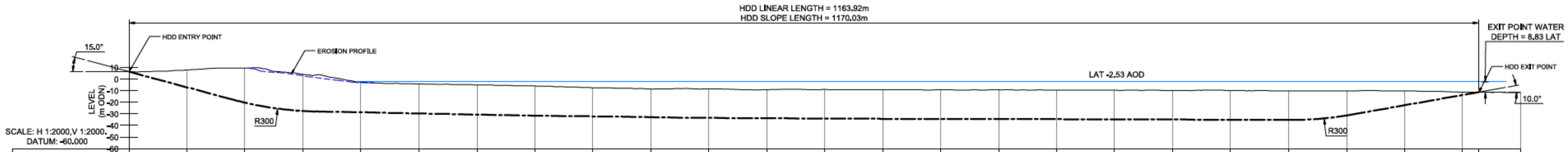
Plotted: 28/02/2020 8:21 AM
Attached Xrefs: 1002_000330-MAE-XX-XX-M2-C-0004_P01_S2 (BACTON PIPELINES).dwg; 1002_000330-MAE-XX-XX-M2-C-0001_P01_S2 (WORKING EXTENTS).dwg

LEGEND:

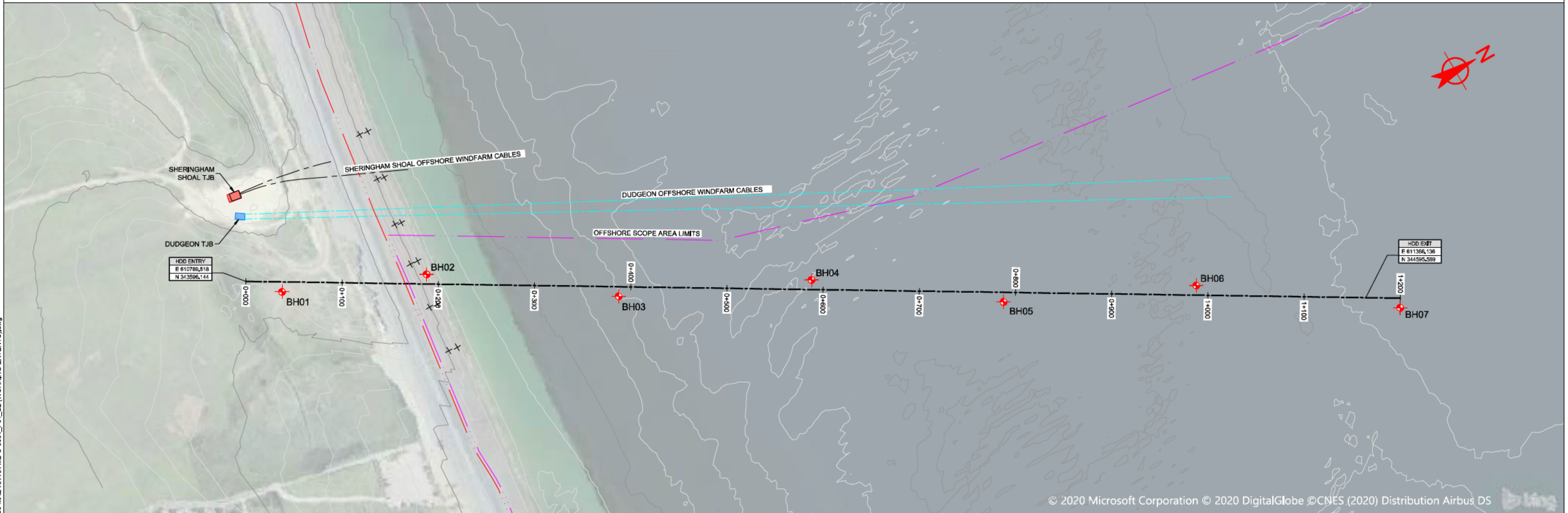
- HDD CENTRELINE
- OFFSHORE SCOPE AREA LIMITS
- ONSHORE SCOPE AREA LIMITS
- EXISTING OFFSHORE CABLES
- PROPOSED BOREHOLES 10m OFFSET FROM DRILL ALIGNMENT

NOTES:

1. ALL DIMENSIONS, LEVELS AND CHAINAGES IN METRES UNLSS OTHERWISE STATED. LEVELS ARE RELATIVE TO O.D. NEWLYN AND CHAINAGES RELATIVE TO ZERO AT HDD ENTRY POINT
2. TOPOGRAPHICAL SUVEY INFORMATION OBTAINED FROM DEFRA DATA SERVICES PLATFORM:
   BATHYMETRY COASTAL MULTIBEAM - 2016
   LIDAR 1m & 2m DTM COMPOSITE - LATEST AVAILABLE DATA
3. GRID CO-ORDINATE SYSTEM OSGB 36
4. THE DETAILS SHOWN ON THI DRAWING ARE FOR STUDY PURPOSES ONLY AND HAVE BEEN PREPARED FROM THE DATA AND INFORMATION AVAILABLE AT THE TIME. DETAILS MAY CHANGE DEPENDING ON THE RESULTS OF FURTHER ENGINEERING AND SURVEYS
5. EXISTING PIPELINE INFORMATION SOURCED FROM OIL & GAS AUTHORITY 'OGA_INFRASTRUCTURE_WGS84'
6. CLIFF EROSION PROFILE BASED ON INFORMATION SOURCED FROM NATIONAL COASTAL EROSION RISK MAPPING (NCERM) 2018-2021



GROUND LEVEL	6.23	-7.17	-20.36	-27.58	-28.75	-29.70	-30.64	-31.59	-32.25	-32.92	-33.57	-33.81	-34.05	-34.28	-34.39	-34.49	-34.60	-34.76	-34.92	-35.08	-35.25	-31.42	-22.64	-13.82	-11.36	
CENTRE OF PIPE	6.23	-7.17	-20.36	-27.58	-28.75	-29.70	-30.64	-31.59	-32.25	-32.92	-33.57	-33.81	-34.05	-34.28	-34.39	-34.49	-34.60	-34.76	-34.92	-35.08	-35.25	-31.42	-22.64	-13.82	-11.36	
COVER TO CENTRELINE	0.00	14.83	29.75	31.47	26.02	25.40	25.55	25.52	24.76	24.47	25.01	24.69	25.01	24.94	25.01	25.16	25.09	24.99	25.02	25.20	24.88	20.97	12.28	2.64	0.00	
CHAINAGE	00.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1050.00	1100.00	1150.00	1163.97	1200.00



MURPHY WORLD-CLASS INFRASTRUCTURE

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

0 50 100 1:2000 200m

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P02	M.ANDERSON	S.BYRNE	J.CURRAN	28/02/20	MINOR AMENDMENTS
P01	J.SLATER	S.BYRNE	J.CURRAN	17/02/20	FOR REVIEW & COMMENT

Project:	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision:	P02
Suitability:	S3
Scale @ A1:	1:2000
Sheets:	1 OF 1
Internal Proj.Ref:	1002_000330
Dwg Title:	LANDFALL HDD PROFILE WEYBOURNE
Dwg No:	1002_000330-MAE-XX-XX-DR-C-0003
Purpose of Issue:	REVIEW & COMMENT
Client Ref Number:	-

Plotted: 28/02/2020 8:40 AM
Attached Xrefs: 1002_000330-MAE-XX-XX-M2-C-0001_P01_S2 (WORKING EXTENTS).dwg

Plotted: 23/02/2020 3:42 AM
Attached Xrefs: 1002_000330-MAE-XX-XX-M2-C-0004_P01_S2 (BACTON PIPELINES).dwg

MURPHY WORLD-CLASS INFRASTRUCTURE

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

-

0 50 100 1:2000 200m

This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P01	K. SWIFT	-	-	22.02.20	FOR REVIEW & COMMENT

Project:	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision:	P01
Suitability:	S3
Dwg Title:	BACTON ACCESS ROUTE REDLINE BOUNDARY
Scale @ A1:	1:1500
Dwg No:	1002_000330-MAE-XX-XX-DR-C-0006
Sheets:	1 OF 1
Purpose of Issue:	REVIEW & COMMENT
Internal Proj.Ref:	1002_000330
Client Ref Number:	-

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. GRID CO-ORDINATE SYSTEM OSGB 36
3. THE DETAILS SHOWN ON THI DRAWING ARE FOR STUDY PURPOSES ONLY AND HAVE BEEN PREPARED FROM THE DATA AND INFORMATION AVAILABLE AT THE TIME. DETAILS MAY CHANGE DEPENDING ON THE RESULTS OF FURTHER ENGINEERING AND SURVEYS
4. EXISTING PIPELINE INFORMATION SOURCED FROM OIL & GAS AUTHORITY 'OGA_INFRASTRUCTURE_WGS84'

MURPHY WORLD-CLASS INFRASTRUCTURE

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

0 50 100 1:2000 200m

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P01	K. SWIFT	-	-	22.02.20	FOR REVIEW & COMMENT

Project:	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision:	P01
Suitability:	S3
Dwg Title:	BACTON HDD & STRINGING SITE REDLINE BOUNDARY
Scale @ A1:	1:2500
Dwg No:	1002_000330-MAE-XX-XX-DR-C-0007
Sheets:	1 OF 1
Purpose of Issue:	REVIEW & COMMENT
Internal Proj.Ref:	1002_000330
Client Ref Number:	-

Plotted: 23/02/2020 3:43 AM
Attached Xrefs: 1002_000330-MAE-XX-XX-M2-C-0004_P01_S2 (BACTON PIPELINES).dwg

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. GRID CO-ORDINATE SYSTEM OSGB 36
3. THE DETAILS SHOWN ON THI DRAWING ARE FOR STUDY PURPOSES ONLY AND HAVE BEEN PREPARED FROM THE DATA AND INFORMATION AVAILABLE AT THE TIME. DETAILS MAY CHANGE DEPENDING ON THE RESULTS OF FURTHER ENGINEERING AND SURVEYS
4. EXISTING PIPELINE INFORMATION SOURCED FROM OIL & GAS AUTHORITY 'OGA_INFRASTRUCTURE_WGS84'

LEGEND:

- HDD CENTRELINE
- EXISTING OFFSHORE CABLES
- ACCESS ROUTE
- HDD RIG SITE AREA

Plotted: 23/02/2020 3:57 AM
Attached Xrefs:

MURPHY
WORLD-CLASS INFRASTRUCTURE

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

equinor

-
-

0 50 100 1:2000 200m

This document is issued for the party which commissioned it and for specific purposes connected with the captioned project only. It should not be relied upon by any other party or used for any other purpose.
We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P01	K. SWIFT	-	-	22/02/20	FOR REVIEW & COMMENT

Project	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision	P01
Suitability	S3
Dwg Title	WEYBOURNE ACCESS ROUTE REDLINE BOUNDARY
Scale @ A1	1:2000
Dwg No	1002_000330-MAE-XX-XX-DR-C-0008
Sheets	1 OF 1
Purpose of Issue	REVIEW & COMMENT
Internal Proj.Ref	1002_000330
Client Ref Number	-

NOTES

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
2. GRID CO-ORDINATE SYSTEM OSGB 36
3. THE DETAILS SHOWN ON THI DRAWING ARE FOR STUDY PURPOSES ONLY AND HAVE BEEN PREPARED FROM THE DATA AND INFORMATION AVAILABLE AT THE TIME. DETAILS MAY CHANGE DEPENDING ON THE RESULTS OF FURTHER ENGINEERING AND SURVEYS
4. EXISTING PIPELINE INFORMATION SOURCED FROM OIL & GAS AUTHORITY 'OGA INFRASTRUCTURE WGS84'

LEGEND

- HDD CENTRELINE
- EXISTING OFFSHORE CABLES
- HDD RIG SITE
- STRINGING SITE

-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
P02	M.ANDERSON	S.BYRNE	J.CURRAN	27/02/20	HISTORICAL WwTW SITE INDICATED
P01	K. SWIFT	-	-	22/02/20	FOR REVIEW & COMMENT
REV	DRAWN	CHK	APP.	DATE	REVISION COMMENTS

Project	EXTENSION OF DUDGEON & SHERINGHAM OFFSHORE WIND FARMS
Revision	P02
Suitability	S3
Dwg Title	WEYBOURNE HDD & STRINGING SITE REDLINE BOUNDARY
Scale @ A1	1:2000
Dwg No	1002_000330-MAE-XX-XX-DR-C-0009
Sheets	1 OF 1
Purpose of Issue	REVIEW & COMMENT
Internal Proj.Ref	1002_000330
Client Ref Number	-

0 50 100 1 2000 200m

J. MURPHY & SONS LTD
Hiview House, Highgate Road, London NW5 1TN

-
-

Plotted: 27/02/2020 10:44 AM
Attached Xrefs: