The Great Grid Upgrade

Sea Link

Sea Link

Volume 6: Environmental Statement

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Part 1 Introduction
Chapter 4
Description of the Proposed Project

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Version History

Date	Issue	Status	Description / Changes
March 2025	A	Final	For DCO submission
May 2025	B	Final	Amended text to improve clarity on the location of figures which are appended to standalone documents
September 2025	C	Final	Update to reflect S89(3) Procedural Decision from the Examining Authority

4. Description of the Proposed Project

4.1 Introduction

4.1.1 The Sea Link Project (hereafter referred to as the 'Proposed Project') is a proposal by National Grid Electricity Transmission plc (hereafter referred to as National Grid) to reinforce the transmission network in the South East of England and East Anglia.

4.1.2 This would be achieved by reinforcing the network with a High Voltage Direct Current (HVDC) Link between the proposed Friston Substation[1] in the Sizewell area of Suffolk and the existing Richborough to Canterbury 400 kV overhead line close to Richborough in Kent. This reinforcement would be approximately 138 km long, comprising primarily of a HVDC offshore transmission link, with both HVDC and High Voltage Alternating Current (HVAC) onshore elements.

4.1.3 This chapter sets out the description of the Proposed Project and has been split into the following sections, which describe:

- the infrastructure proposed in Suffolk, Kent and in the marine environment;
- the construction methods that are proposed for installing the infrastructure associated with the Proposed Project;
- operation and maintenance requirements; and
- how the Proposed Project is proposed to be decommissioned if required.

4.1.4 This chapter should be read in conjunction with:

- **Application Document 6.2.1.1 Part 1 Introduction Chapter 1 Introduction**;
- **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**;
- **Application Document 7.5.2 Outline Offshore Construction Environmental Management Plan**;
- **Application Document 7.5.3 Outline Onshore Construction Environmental Management Plan**;
- **Application Document 7.5.3.1 CEMP Appendix A Outline Code of Construction Practice**;
- **Application Document 7.5.3.2 CEMP Appendix B Register of Environmental Actions and Commitments (REAC)**;
- **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**; and

[1] The name 'Friston Substation' is used throughout the Proposed Project's DCO Application solely as a geographic term to identify the site of the substation at Friston. The use of the term is not intended to establish a permanent name for this substation. National Grid has committed to engage with the local community over a permanent name for this substation, and will continue this process in parallel to the DCO Application.

- **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**.

4.1.5 This chapter is supported by the following appendices:

- **Application Document 6.3.1.4.A Appendix 1.4.A Crossings Schedules**; and
- **Application Document 6.3.1.4.B Appendix 1.4.B Construction Plant Schedule**.

4.1.6 This chapter is supported by the following plans, figures and drawings:

- **Application Document 2.5.1 Work Plans – Suffolk**;
- **Application Document 2.5.2 Work Plans – Kent**;
- **Application Document 2.5.3 Work Plans – Offshore**;
- **Application Document 2.6.1 Traffic and Regulation Order Plans – Suffolk**;
- **Application Document 2.6.2 Traffic and Regulation Order Plans – Kent**;
- **Application Document 2.7.1 Access, Rights of Way and Public Rights of Navigation Plans – Suffolk**;
- **Application Document 2.7.2 Access, Rights of Way and Public Rights of Navigation Plans – Kent**;
- **Application Document 2.12.1 Trees and Hedgerows to be Removed or Managed Plans – Suffolk**;
- **Application Document 2.12.2 Trees and Hedgerows to be Removed or Managed Plans – Kent**;
- **Application Document 2.13.1 Design Drawings – Suffolk**;
- **Application Document 2.13.2 Design Drawings – Kent**;
- **Application Document 2.13.3 Design Drawings - Terrestrial General**;
- **Application Document 2.13.4 Design Drawings – Offshore**;
- **Application Document 2.14.1 General Arrangements Plans – Suffolk**;
- **Application Document 2.14.2 General Arrangements Plans – Kent**;
- **Application Document 2.14.3 General Arrangements Plans – Marine**;
- **Application Document 6.4.1.4 Description of the Proposed Project**;
- **Application Document 7.5.7.1.1 Saxmundham Converter Station Outline Landscape Mitigation** which are appended to **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**;
- **Application Document 7.5.7.1.2 Saxmundham Converter Station Illustrative Cross Sections** which are appended to **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**;
- **Application Document 7.5.7.1.3 Saxmundham Converter Station Outline Landscape Mitigation - Timing of Planting** which are appended to **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**;

- **Application Document 7.5.7.1.4 Saxmundham Converter Station Enhancement Areas** which are appended to **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**;
- **Application Document 7.5.7.1.5 Friston Substation Outline Landscape Mitigation** which are appended to **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**;
- **Application Document 7.5.7.2.1 Minster Converter Station and Substation Outline Landscape Mitigation** which are appended to **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**;
- **Application Document 7.5.7.2.2 Minster Converter Station and Substation Illustrative Cross Sections** which are appended to **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**;
- **Application Document 7.5.7.2.3 Minster Converter Station and Substation Outline Landscape Mitigation - Timing of Planting** which are appended to **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**; and
- **Application Document 7.5.7.2.4 Minster Converter Station and Substation Enhancement Areas** which are appended to **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**.

4.1.7 As described in **Application Document 6.2.1.1 Part 1 Introduction Chapter 1 Introduction** for ease of presentation the Proposed Project has been split geographically into the Suffolk Onshore Scheme, Kent Onshore Scheme and the Offshore Scheme, the following sections describe the infrastructure proposed in each of these areas.

4.2 Suffolk Onshore Scheme

4.2.1 The Order Limits in Suffolk (also referred to as 'Suffolk Onshore Scheme Boundary') are illustrated on **Application Document 2.2.2 Suffolk Location Plan**. The Suffolk Onshore Scheme comprises of:

- A connection from the existing transmission network via Friston Substation, including the substation itself. Friston Substation already has development consent as part of other third-party projects. If Friston Substation has already been constructed under another consent, only a connection into the substation would be constructed as part of the Proposed Project.
- A HVAC underground cable of approximately 1.9 km in length between the proposed Friston Substation and a proposed converter station (below).
- A 2 GW HVDC converter station (including permanent access from the B1121 and a new bridge over the River Fromus) up to 26 m high plus external equipment (such as lightning protection, safety rails for maintenance works, ventilation equipment, aerials, similar small scale operational plant, or other roof treatment) near Saxmundham.
- A HVDC underground cable connection of approximately 10 km in length between the proposed converter station near Saxmundham, and a transition joint bay (TJB) approximately 900 m inshore from a landfall point (below) where the cable transitions from onshore to offshore technology.

- A landfall on the Suffolk coast (between Aldeburgh and Thorpeness).

Proposed Friston Substation

4.2.2 The proposed Friston Substation is located to the north of the village of Friston and to the south of the existing 4ZW and 4ZX overhead lines and centered on Grid Reference TM4130961290 as illustrated on **Application Document 2.14.1 General Arrangements Plans - Suffolk**.

4.2.3 Friston Substation already benefits from development consent granted to Scottish Power Renewables (SPR), pursuant to 'The East Anglia ONE North (EA1N) Offshore Wind Farm Order 2022' and 'The East Anglia TWO (EA2) Offshore Wind Farm Order 2022'. Given that these consents have yet to be implemented, the Friston Substation is included in the Proposed Project to achieve a comprehensive consenting position.

4.2.4 **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology** sets out the two scenarios assessed within each of the technical assessment chapters in Part 2 of the Environmental Statement (ES). The first scenario is that Friston Substation is constructed under the SPR consent (with the Proposed Project only needing to build a connection into it), with the second scenario assuming Friston Substation is built as part of the Proposed Project.

4.2.5 The current intention is that Friston Substation would be constructed pursuant to the SPR consent (the first scenario). Construction is planned to commence in 2026, likely prior to a decision being made on the Development Consent Order application for the Proposed Project. National Grid is working closely with SPR to provide design information to feed into final management plans and other documents for the discharge of requirements on the SPR consents to enable construction to commence on programme. Under the first scenario, whilst Friston Substation would be constructed pursuant to the SPR consent, as a transmission asset it would be constructed by National Grid as an agent to the SPR application rather than by SPR. The second scenario would only occur if the SPR projects do not proceed and Friston Substation is no longer constructed under that consent. The second scenario is considered to highly unlikely to occur.

4.2.6 The parameters for the Friston Substation are consistent between the two SPR DCOs and the DCO application for the Proposed Project. However, there are intentional differences in how the applications have been put together and the details of proposed controls for three key reasons. Firstly, as the design has moved on since the granting of the SPR DCOs in 2022, the Proposed Project is able to provide more certainty on design elements than was possible in the SPR consents. For example, it is now known that the Friston Substation will be a gas insulated switchgear substation rather than an air insulated switchgear substation, so there is no need for the Proposed Project to include both options as were included in the SPR consents. The gas insulated switchgear substation would require a significantly smaller footprint than the now rejected alternative. The final plans submitted to discharge requirements on the SPR consent will reflect this detail. Therefore, in this Environmental Statement, both scenarios assess the impacts of a gas insulated switchgear substation.

4.2.7 Secondly, in the event that the Friston Substation was constructed without the SPR project proceeding there may be differences in how the site is developed because, for example, there may be less won material generated from the construction of the adjacent two SPR substations; and/ or the final Landscape and Ecological Management

Plan may be different to account for there being no adjacent development. This is a scenario that the SPR consents did not need to consider.

4.2.8 Finally, the SPR DCOs consent offshore windfarms and the Proposed Project includes converter stations in Suffolk and Kent and 122 km of offshore cable. Therefore, the Friston Substation is a small component of both projects and the majority of the requirements and controls for both projects were written for elements outside the area of overlap. Even at the Friston site there are three proposed substations, of which only one is part of the Proposed Project. The three projects also have different programmes and drivers; and National Grid is subject to statutory duties and licence conditions that do not apply in the same way to SPR.

4.2.9 For all the above reasons, whilst the parameters of the design are consistent between the Proposed Project and the SPR consents, there are intentional differences between the controls on development and how they are secured.

Scenario whereby Friston Substation is built as part of the Proposed Project

4.2.10 The proposed Friston Substation would be constructed using gas insulated technology, with a footprint of up to 16,800 m^2 (excluding drainage, access and landscaping works).

4.2.11 The substation is likely to comprise one or more buildings which could house services, storage workshop, and relay room, along with a backup diesel generator. The substation compound would include hard and soft landscaping, the substation would be enclosed by a fence and would contain a parking area and access road. Friston substation would also include cable sealing ends (CSE) which are vertical structures allowing the cables to exit the ground and connect to solid bars, known as busbars, at approximately 8.45 m height above ground. They would be combined with surge arrestors, metering and other ancillary equipment required to allow for the transition from above ground infrastructure to underground cables.

4.2.12 The proposed infrastructure required for the Proposed Project at Friston is shown indicatively in red on **DCO/S/DE/SS/12010** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings Suffolk**).

4.2.13 The construction of the substation would also require modification works to the adjacent existing 400 kV overhead line. The 4ZW 400 kV route would need to be modified to accommodate a double circuit turn in and out of the proposed Friston Substation. This would involve removal of one existing 4ZW 400 kV overhead line pylon (4ZW020), and installation of two new pylons on the 4ZW 400 kV overhead line (4ZW020A and 4ZW020B). Installation of approximately two temporary masts/temporary towers would be required to facilitate the connection to the new substation. It could also include the re-conductoring of a short length of the 4ZW 400 kV overhead line and minor alterations to the pylons approaching the proposed Friston Substation (4ZW015 to 4ZW024).

4.2.14 Proposed works to the existing 4ZW 400 kV overhead line are shown in **Application Document 2.14.1 General Arrangement Plans – Suffolk**, with details of the modification works provided in Table 4.1 below.

Table 4.1 Typical characteristics of 4ZW overhead line

Characteristic	Proposed Project Indicative Description
Pylon type	Steel lattice – typical standard height, 90 degree bends
Pylon height	Typically 54 m (standard height)
Pylon footprint	Typically 340 m^2 (standard height)
Span distance	Typically 350 m
Land rights swathe	40-60 m
Line Section length (section 4ZW19-4ZW27)	2.93 km
New Line Section length (section 4ZW19-4ZW20A)	0.33 km
New Line Section length (section 4ZW20B-4ZW27)	2.5 km
Conductor type	4 x 400 mm^2 ACSR Zebra
Number of phases and earthwires	7
Number of phase sub conductors	4

4.2.15 A typical standard height pylon is illustrated on **DCO/T/DE/SS/1304** of **Application Document 2.13.3 Design Drawings - Terrestrial General** and the indicative pylon types and heights are detailed in Table 4.2 which would be subject to the Limit of Deviation (LoD) defined below.

Table 4.2 4ZW overhead line indicative pylon types and heights

Pylon Name	Pylon Condition	Pylon Type	Indicative Height (m)
4ZW19	Existing to be maintained	L6 BB D60 E10	53.378
4ZW20A	New to be installed	L6 BB DT E10 (auxiliary cross-arms)	53.594
4ZW20B	New to be installed	L6 BB DT E10 (auxiliary cross-arms)	53.594
4ZW21	Existing to be maintained	L6 BB D E20	56.134
4ZW20A/B	Temporary mast	MAST E3*	35.600

** Temporary pylons that would be similar to the standard permanent pylons, may be used instead of temporary masts.*

~~4.2.17~~4.2.16 A permanent access road is proposed from the B1121 Saxmundham Road to the west of the proposed Friston Substation to allow operational vehicular access to the substation. A permanent bellmouth (S-BM11) would be constructed to allow vehicles to turn safely from the B1121 into the access road as shown in **Application Document 2.7.1 Access, Rights of Way and Public Rights of Navigation Plans – Suffolk**. The runoff from the access road would be collected via filter drains/ditches along the edge of the road and directed to a permanent infiltration/attenuation pond that would in turn discharge to the closest watercourse as shown in **Application Document 2.14.1 General Arrangement Plans - Suffolk**.

~~4.2.18~~4.2.17 A permanent water supply would be connected to the proposed Friston Substation to support operational needs, including welfare. Where supplies are not suitable for hydrant systems a trickle feed water tank would be provided to supply water for firefighting purposes.

~~4.2.19~~4.2.18 In addition, landscape proposals at Friston include the provision of extensive species-rich neutral grassland to the north and west of the proposed Friston Substation, woodland planting to the south along Grove Road and riparian planting around the permanent infiltration/attenuation pond. The species-rich neutral grassland would provide a low maintenance ground cover which also provides local biodiversity in areas that are not to be returned to agricultural use or planted as woodland. Woodland planting is proposed to both screen and integrate the Friston Substation into the landscape and views. The landscape proposals are shown in **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**.

~~4.2.20~~4.2.19 Design principles for Friston Substation have been provided with the application for development consent. These provide guidance regarding the design intent that would be adopted for the detailed proposals of the structure. Further details can be found within **Application Document 7.11.1 Design Approach Document – Suffolk** and **Application Document 7.12.1 Design Principles – Suffolk Table 4.1**.

Scenario whereby Friston Substation is built by SPR

~~4.2.21~~4.2.20 Should the proposed Friston Substation be installed under the current consent secured by SPR, the works required for the Proposed Project would be limited to the installation of new gas insulated switchgear (GIS) bays and additional switch gear, CSE and associated outdoor structures, cable connections and busbars, all within the boundary of the substation, and the routing of the HVAC cables to the substation. This is illustrated indicatively in red on **DCO/S/DE/SS/1200** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**). No works would therefore be required to the existing overhead line, as the new substation would already be connected to the network via the existing line. Similarly, other works associated with the construction of the proposed Friston Substation would also not be required under this scenario, including the permanent access road from the B1121, drainage and landscaping works described above. The figure **Application Document 6.4.1.4.9 Friston Substation Scenario 1 (built by others)** included with this ES illustrates which works would be built by others and do not form part of the Proposed Project in this scenario.

~~4.2.22~~4.2.21 It is currently assumed that in advance of Sea Link, permanent access, drainage and some advance planting would be installed as part of the SPR East Anglia ONE North and TWO projects.

Limits of Deviation

4.2.234.2.22 For the scenario where Friston Substation is built as part of the Proposed Project, the lateral LoD is illustrated on **Application Document 2.5.1 Work Plans - Suffolk**. The shape and arrangement of the substation may vary within the LoD however it would not be greater than the 16,800 m^2 area indicated.

4.2.244.2.23 The vertical LoD would include creating a level platform for the works which would involve cut and fill works to create the platform. The maximum height of any buildings or structures on the site above the platform would be 18 m plus roof equipment such as lightning rods, handrails and roof mounted plant. This is illustrated in **DCO/S/DE/SS/1206** of **Application Document 2.13.1 Design Drawings Suffolk**.

4.2.254.2.24 The vertical above ground LoD for the overhead line modification works for the scenario where Friston Substation is built as part of the Proposed Project is 6 m above the indicative height.

Proposed HVAC Connection

4.2.264.2.25 The proposed HVAC connection would be located between the proposed Friston Substation and the proposed Saxmundham Converter Station via HVAC underground cables. It would be routed northwest from the proposed Friston Substation for approximately 1.9 km.

4.2.274.2.26 A typical HVAC construction swathe is illustrated on **DCO/S/DE/SS/1202** of **Application Document 2.13.1 Design Drawings - Suffolk** and a typical HVAC joint bay arrangement is illustrated on **DCO/S/DE/SS/1203** of **Application Document 2.13.1 Design Drawings - Suffolk**.

4.2.284.2.27 Between the proposed Friston Substation and Saxmundham Converter Station the HVAC and HVDC cables for the Proposed Project would be combined within the same construction swathe, this is illustrated on **DCO/S/DE/SS/1204** of **Application Document 2.13.1 Design Drawings - Suffolk**.

4.2.294.2.28 Table 4.3Table 4.3Table 4.3 provides a summary of the typical characteristics of an HVAC connection and a combined HVAC and HVDC cable corridor.

Table 4.3 Typical characteristics of the Proposed Project HVAC connection and a combined HVAC/HVDC cable corridor

Characteristic	Proposed Project Indicative Description
Working width	Typically 63 m (HVAC corridor only) Typically 78 m (combined HVDC and HVAC corridors)
Permanent easement	Typically 63 m (HVAC corridor only) Typically 78 m (combined HVDC and HVAC corridors)
Total length of HVAC cable route	1.9 km
No of HVAC cables	Up to six cables

Characteristic	Proposed Project Indicative Description
No of trenches	Up to two (HVAC corridor only) Up to three (combined HVAC and HVDC corridors)
Trench width	Typically 2.5 m
Trench depth	Typically 1.5 m
Number of ducts	Eight ducts (six cable and two fibre optic split over the two trenches) two Distributed Temperature Sensing (DTS) tubes.
Minimum depth of cover	Agricultural land – typically 0.9 m (900 mm) Watercourses – typically 0.9 m (900 mm) varies per type of watercourse and owner Roads – typically 0.75 m (750 mm) Railways – typically 1.4 m (1400 mm) Footpaths and non-agricultural verges – typically 0.9 m (900 mm)
Backfill material	Soil and cement bound sand (CBS) or other thermally suitable material. Typically, all topsoil would be retained and used during reinstatement. Where suitable, subsoil is retained and used to backfill the trenches above the duct and CBS installation. As the installation of the ducts and CBS surround would typically take up approximately half the volume of the sub soil excavated, there would be excess sub soil following reinstatement. Any excess subsoil would either be retained for use on site, such as for landscaping or removed from site.
Cable section length	Typical cable section length: 800 m–1200 m
Above ground infrastructure	At each cable joint bay there would be an above ground kiosk, which would be used to monitor and occasionally test the underground cables. For the Proposed Project, it is likely that there would be two HVAC circuits each containing three cables, there would be a joint bay per circuit wherever cables need to be jointed and a kiosk per joint bay. Generally, the joint bays for the circuits would be aligned so that they are roughly in the same location, therefore in each of these locations you would expect to see two above ground kiosks, one for each circuit.

Limit of Deviation

4.2.304.2.29 The lateral LoD is illustrated on **Application Document 2.5.1 Work Plans - Suffolk**. The minimum burial depths are detailed in Table 4.3Table 4.3Table 4.3. No lowest below ground vertical LoD has been specified, this is because to place a limit may unnecessarily restrict below ground works where there is little or no chance of likely significant effects resulting. For example, it may be necessary to undertake archaeological excavation, and to have placed a limit on the depth of such excavation works would be unnecessarily restrictive. A standard below ground LoD is not therefore proposed. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Proposed Saxmundham Converter Station

4.2.314.2.30 The proposed Saxmundham Converter Station is located to the east of the settlement of Saxmundham and south of the B1119, centred on Grid Reference TM3977362263. illustrated on **Application Document 2.14.1 General Arrangements Plans - Suffolk**.

4.2.324.2.31 A typical arrangement for the Saxmundham Converter Station is illustrated on Design **DCO/S/DE/SS/1205** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings – Suffolk**). The proposed Saxmundham Converter Station would include a Direct Current (DC) hall, converter transformers, valve hall, reactor hall, Alternating Current (AC) switchyard, control building, strategic spare parts building, Low Voltage (LV) electricity supply, fire deluge pump house, car parking, a permanent access road and landscaping. An indicative 3D view of the proposed Saxmundham Converter Station is shown in Plate 4.1.

Plate 4.1 Indicative 3D view of the Proposed Saxmundham Converter Station

4.2.344.2.32 The Saxmundham Converter Station would be up to 6.5 ha in area (excluding landscaping and drainage and access) and the valve halls could be up to 26 m in height excluding lightning protection, aerials, walkways, fall arrest equipment and potential architectural treatments (such as soft landscaping). Typical elevations are illustrated in **DCO/S/DE/SS/1207** and **DCO/S/DE/SS/1208** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**).

4.2.354.2.33 Permanent access to the converter station would be taken off the B1121 (via proposed bellmouth S-BM09) as shown in **Application Document 2.7.1 Access, Rights of Way and Public Rights of Navigation Plans – Suffolk**.

4.2.364.2.34 A new permanent bridge would be required over the River Fromus. This bridge would have either a 4 m or 2 m clearance from the top of the bank to proposed sofit level. This corresponds to a bridge height of up to 6 m or 4 m from the ground level at the abutment to the top of the parapet (and 6 m or 4 m clearance of the bridge soffit from the Q95 flow level of the river), referred to as Option 1 and Option 2 respectively. Table 4.4 below provides approximate dimensions for the River Fromus bridge crossing structure subject to detailed design and further surveys. The two options are also illustrated in **DCO/S/DE/SS/1210** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**). Lighting would not be provided on this new bridge or the approach to the bridge.

Table 4.4 Approximate dimensions for the River Fromus bridge crossing structure

Option	Clear Span	Width of Bridge Structure	Assumed Width of Channel	Setback of Abutment and Wing Walls	Height of Soffit Above Top of Bank	Height of Parapet	Combined Depth of Bridge Deck and Parapet	Clear Space Between Parapets	Distance from Top of Parapet to Ground Level at Abutments	Approximate Slope of Approach Ramps	Approximate Length of Approach Ramps
Option 1: 6 m clearance of the bridge soffit from the Q95 flow level of the river	24 m	6 m	8 m	Minimum of 8 m	4.0 m	1 m	Between 2.4 m and 2.55 m	Minimum of 5.5 m	Approximately 6 m	1 in 16 for Approach Ramps 1 in 3 for Earthworks Slope to the side of Approach Ramps	62 m
Option 2: 4 m clearance of the bridge soffit from the Q95 flow level of the river	24 m	6 m	8 m	Minimum of 8 m	2.0 m	1 m	Between 2.4 m and 2.55 m	Minimum of 5.5 m	Approximately 4 m	1 in 16 for Approach Ramps 1 in 3 for Earthworks Slope to the side of Approach Ramps	42 m

4.2.374.2.35 The runoff from the non-permeable areas of the converter station site (buildings, internal roads, car parks and external access roads) would discharge into a proposed permanent attenuation pond which would ultimately outfall to an existing watercourse as shown in **Application Document 2.14.1 General Arrangement Plans - Suffolk**.

4.2.384.2.36 A permanent water supply would be connected to the proposed Saxmundham Converter Station to support operational needs, including welfare. Where supplies are not suitable for hydrant systems a trickle feed water tank would be provided to supply water for firefighting purposes.

4.2.394.2.37 Landscape proposals at Saxmundham Converter Station are shown in **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk**.

Lighting

4.2.404.2.38 The external lighting system at the proposed Converter Station would meet the requirements of National Grid TS 2.10.04 Issue 1- 2017. This specifies that the minimum exterior lighting requirements are as follows.

- Maintained average illuminance: 6.0 lux.
- Maintained minimum point Illuminance: 2.5 lux.

4.2.414.2.39 The external lighting would allow the safe movement of vehicles and pedestrians between any two points that they may reasonably expected to negotiate during the hours of low light or darkness within the site perimeter. The external lighting is not intended to facilitate maintenance activities for which it is assumed that additional portable equipment would be employed. Luminaires would be Light-Emitting Diodes (LED) type fittings.

4.2.424.2.40 Road and site lighting would be provided using road lanterns and floodlights. Wherever possible, road lantern and floodlight type luminaires would be mounted upon dedicated 8 m, galvanised steel, base-hinged columns designed to be lowered for maintenance purposes. Building mounted luminaires would provide amenity lighting to footpaths throughout the site.

Design

4.2.434.2.41 The architectural design of Saxmundham Converter Station may vary within the physical parameters and LoDs set out above. The design of this structure, in terms of the building form and the external materials, has been developed alongside consultation and stakeholder feedback as well as Design Panel Review. Design principles for the building have been developed and are provided with the application for development consent (**Application Document 7.12.1 Design Principles – Suffolk Table 3.1**). The Design Principles provide guidance regarding the design intent and design principles that would be adopted and embedded into the detailed design proposals of this structure. The approach to design is also covered within **Application Document 7.11.1 Design Approach Document – Suffolk**.

Limits of Deviation

4.2.444.2.42 The lateral LoD is illustrated on **Application Document 2.5.1 Work Plans - Suffolk.** The extent of the lateral LoD allows for the necessary flexibility for the design process to continue to develop so that the most suitable position for the Saxmundham

Converter Station can be delivered. The shape and arrangement of the converter compound may vary within the LoD however would not be greater than the 65,000 m^2.

4.2.454.2.43 The vertical LoD for the proposed Saxmundham Converter Station is 26 m excluding lightning protection, aerials, walkways, fall arrest equipment and potential architectural treatments (such as soft landscaping) as illustrated in **DCO/S/DE/SS/1207** and **DCO/S/DE/SS/1208** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**). No lowest below ground vertical LoD has been specified. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Proposed Underground HVDC Cables

4.2.464.2.44 The proposed HVDC underground cables would be routed from the proposed Saxmundham Converter Station to the proposed Suffolk Landfall. They would be routed southeast from Saxmundham Converter Station passing to the north of the proposed Friston substation, south of Great Wood and north of the A1094. They would then be routed to the north of Old Broom Covert, Eight Acre Covert and Aldeburgh Golf Course crossing the B1122 Leiston Road. The TJB located to the north of Warren Hill Lane and south of Sandlings Special Protection Area (SPA).

4.2.474.2.45 A typical HVDC construction swathe is illustrated on **DCO/S/DE/SS/1209** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**) and a typical HVDC joint bay arrangement is illustrated on **DCO/T/DE/SS/1301** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**).

4.2.484.2.46 As mentioned above, between the proposed Friston Substation and the proposed Saxmundham Converter Station the HVAC and HVDC cables for the Proposed Project would be combined within the same construction swathe, this is illustrated on **DCO/S/DE/SS/1204** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**).

4.2.494.2.47 Table 4.5 provides a summary of the typical characteristics of the HVDC underground cables. Table 4.3Table 4.3Table 4.3 above provides a summary of the typical characteristics of the combined HVAC and HVDC cable corridor.

Table 4.5 Typical characteristics of HVDC underground cables

Characteristic	Proposed Project Indicative Description
Working width	Typically 40 m
Permanent easement	Typically 40 m
No of HVDC cables	Up to two
No of trenches	Up to one
Total length of HVDC cable route	10 km
Trench width	Typically 2.3 m
Trench depth	Typically 1.5 m

Characteristic	Proposed Project Indicative Description
Number of ducts	Three (two cables and one fibre)
Minimum depth of cover	Agricultural land – typically 0.9 m (900 mm) Watercourses – typically 0.9 m (900 mm) varies per type of watercourse and owner Roads – typically 0.75 m (750 mm) Railways – typically 1.4 m (1400 mm) Footpaths and non-agricultural verges – typically 0.9 m (900 mm)
Backfill material	Soil and CBS or other thermally suitable material. Typically, all topsoil would be retained and used during reinstatement. Where suitable sub soil is retained and used to backfill the trenches above the duct and CBS installation. As the installation of the ducts and CBS surround would typically take up approximately half the volume of the sub soil excavated, there would be excess sub soil following reinstatement. Any excess sub soil would either be retained for use on site, such as for landscaping or removed from site.
Cable section length	Typical cable section length: 800 m–1200 m
Above ground infrastructure	There is no above ground infrastructure associated with the HVDC installation other than the terminations which would be within the Converter stations.

Limit of Deviation

4.2.504.2.48 The lateral LoD is illustrated on **Application Document 2.5.1 Work Plans - Suffolk**.

4.2.514.2.49 The minimum burial depths are detailed in Table 4.5. No lowest below ground vertical LoD has been specified, this is because to place a limit may unnecessarily restrict below ground works where there is little or no chance of likely significant effects resulting. For example, it may be necessary to undertake archaeological excavation, and to have placed a limit on the depth of such excavation works would be unnecessarily restrictive. A standard below ground LoD is not therefore proposed. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Suffolk Landfall

4.2.524.2.50 This is the transition point from the underground HVDC cable to marine HVDC cable. The Suffolk landfall is located north of the settlement of Aldeburgh and south of the settlement of Thorpeness. The marine HVDC cables would cross under Leiston-Aldeburgh Site of Special Scientific Interest (SSSI), North Warren Royal Society for the Protection of Birds (RSPB) Reserve and Thorpe Road.

4.2.534.2.51 The indicative location of the TJB is illustrated on **Application Document 2.14.1 General Arrangement Plans – Suffolk**. Whilst the location of the TJB is indicative within the LoD, there is a commitment to make landfall using a trenchless crossing technique beneath designated sites, the location of the transition joint bay would be located outside of the coastal designated sites of Leiston Aldeburgh Site of SSSI and North Warren RSPB Reserve.

4.2.544.2.52 For the Proposed Project four ducts would be installed, one more duct would be installed than for the underground HVDC cable should a section of cable need to be replaced at the landfall this additional duct would allow for a new section of cable to be pulled through rather than a repair to the existing or needing to re install ducts at the landfall.

Limits of Deviation

4.2.554.2.53 The lateral LoD is illustrated on **Application Document 2.5.1 Work Plans - Suffolk**. No lowest below ground vertical LoD has been specified. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

4.3 Kent Onshore Scheme

4.3.1 The Order Limits in Kent (also referred to as 'Kent Onshore Scheme Boundary') are illustrated on **Application Document 2.2.3 Kent Location Plan**. The Kent Onshore Scheme would comprise of:

- A landfall point on the Kent coast at Pegwell Bay.
- A TJB approximately 800 m inshore to transition from offshore HVDC cable to onshore HVDC cable, before continuing underground for approximately 1.7 km to a new converter station (below).
- A 2 GW HVDC converter station (including a new permanent access off the A256), up to 28 m high plus external equipment (such as lightning protection, safety rails for maintenance works, ventilation equipment, aerials, and similar small scale operational plant), near Minster. A new substation would be located immediately adjacent.
- Removal of approximately 2.2 km of existing HVAC overhead line, and installation of two sections of new HVAC overhead line, together totalling approximately 3.5 km, each connecting from the substation near Minster and the existing Richborough to Canterbury overhead line.

Proposed HVAC Connection

4.3.2 To facilitate the Proposed Project the existing 400 kV PC route in Kent would need to be modified to accommodate a double circuit turn in and out of the proposed Minster 400 kV Substation. The HVAC connection from the existing Richborough to Canterbury 400 kV overheard line to the proposed Minster 400 kV Substation would be made via a new approximately 3.5 km overhead line (of which 2.2 km would be replacement of existing Richborough to Canterbury connection). The proposed new section of overhead line would be routed to the northeast from the existing Richborough to Canterbury overhead line, crossing the River Stour and a section of railway, and connecting into the proposed Minster 400 kV Substation at approximately Grid Reference TR3216163008.

4.3.3 Table 4.6Table 4.6Table 4.6 provides a summary of the typical characteristics of an overhead line.

Table 4.6 Typical characteristics of Proposed Project PC overhead line modifications

Characteristic	Proposed Project Indicative Description
Pylon type	Steel lattice – typical standard height, 60 degree bends
Pylon height	Typically 46.5 m (standard height) and 41.4 m (low height - PC52A only)
Pylon footprint	Typically 113.54 m^2 (standard height) and 105 m^2 (low height – PC52A only)
Span distance	Typically 350 m
Right of way (ROW) width	40 – 60 m
Removal of Existing Line Section length (section PC51-PC57)	2.2 km
New Line Section length (section PC51-PC53D) New Line Section length (section PC54A-PC57)	1.7 km 1.8 km
Conductor type	2x 591 mm^2 Curlew (ACCR) per phase or similar.
Number of phases and earthwires	7
Number of phase sub conductors	2
Turn in	This would require the installation of approximately nine new standard height pylons (L8 pylon type) and the removal of two existing low height pylons. The existing overhead line route would be diverted to the proposed Minster Substation. Installation of up to six temporary pylons or guyed masts would be required to facilitate the connection to the new substation. This is illustrated on **Application Document 2.14.2 General Arrangement Plans - Kent.**

4.3.4 A typical standard height pylon is illustrated on **DCO/T/DE/SS/1304** of the Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**). The pylon heights detailed in Table 4.6 are the typical heights of the tower types to be used. The indicative pylon types and heights are detailed in Table 4.7~~Table 4.7~~Table 4.7 which would be subject to the LoD defined below.

Table 4.7 PC overhead line indicative pylon types and heights

Tower Name	Tower Condition	Tower Type	Indicative Height (m)
PC51	Existing to be maintained	L12 LD30 E9	44.400
PC52	Existing to be maintained	L12 LD E6	41.300
PC52A	New to be installed	L12 LD30 E6	41.400
PC53A	New to be installed	L8(c) D60 E3.7	48.159
PC53B	New to be installed	L8(c) D E3.7	50.089
PC53C	New to be installed	L8(c) D STD	46.431
PC53D	New to be installed	L8(c) DT STD	46.177
PC54A	New to be installed	L8(c) DT STD	46.177
PC54B	New to be installed	L8(c) D STD	46.431
PC54C	New to be installed	L8(c) D STD	46.431
PC55A	New to be installed	L8(c) D60 E3.7	48.159
PC55	Existing to be maintained	L12 LD E6	41.300
PC56	Existing to be maintained	L12 LD E6	41.300
PC57	Existing to be maintained	L12 LD30 E6	41.400
PC51TA/B/C PC57TA/B/C	Temporary tower	L6 ST E3	48.200

Limits of Deviation

4.3.5 The lateral LoD is illustrated on **Application Document 2.5.2 Works Plans - Kent**. The vertical above ground LoD is 6 m above the indicative height. No vertical below ground LoD has been specified, this is because to place a limit may unnecessarily restrict below ground works where there is little or no chance of likely significant effects resulting. For example, it may be necessary to undertake archaeological excavation, and to have placed a limit on the depth of such excavation works would be unnecessarily restrictive. However, the difference in the effects caused by such depth differences, (largely dependent upon the type of foundation used) would be likely to be very small. A standard LoD below ground is not therefore proposed. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Proposed Minster 400 kV Substation and Minster Converter Station

4.3.6 As the HVAC connection in Kent is being made directly onto the existing Richborough to Canterbury overhead line there is a requirement for a new substation (hereafter referred to as Minster 400 kV substation) to be sited adjacent to Minister Converter Station. The proposed Minster 400 kV Substation and Minster Converter Station are located to the north of Richbourgh Energy Park and a section of Sandwich Bay to Hacklinge Marshes SSSI, and to the west of the A256. Minster 400 kV substation is approximately centred on Grid Reference TR3216163008 and Minster Converter Station on approximately Grid Reference TR3236963071. The total land needed for the combined area of the proposed Minster 400 kV substation and Minster Converter Station would be approximately 9 ha.

4.3.7 The indicative location of the Minster 400 kV substation and Minster Converter Station is illustrated on **Application Document 2.14.2 General Arrangement Plans - Kent**.

Minster 400kV Substation

4.3.8 An indicative arrangement for the proposed Minster 400 kV substation is illustrated on **DCO/K/DE/SS/1250** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings - Kent**) and would comprise a 400 kV substation, anticipated to contain primarily GIS within a GIS building, but also including air insulated elements. The various primary plant and secondary equipment includes, but is not limited to, circuit breakers, disconnectors, earth switches, busbars, and cable interface. A typical 400 kV GIS substation elevation drawing is presented in **DCO/K/DE/SS/1252** and **DCO/K/DE/SS/1253** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings - Kent**).

Minster Converter Station

4.3.9 A typical arrangement for the proposed Minster Converter Station is illustrated on **DCO/K/DE/SS/1251** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings - Kent**).The proposed Minster Converter Station would comprise of a DC hall, converter transformers, valve hall, reactor hall, AC switchyard, control building, strategic spare parts building, LV electricity supply, fire deluge pump house, car parking, a permanent access road and landscaping. A typical elevation drawing for Minster Converter Station is presented in **DCO/K/DE/SS/1254** and **DCO/K/DE/SS/1255** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings - Kent**). An indicative 3D view of the proposed Minster Converter Station and Substation is shown in Plate 4.2.

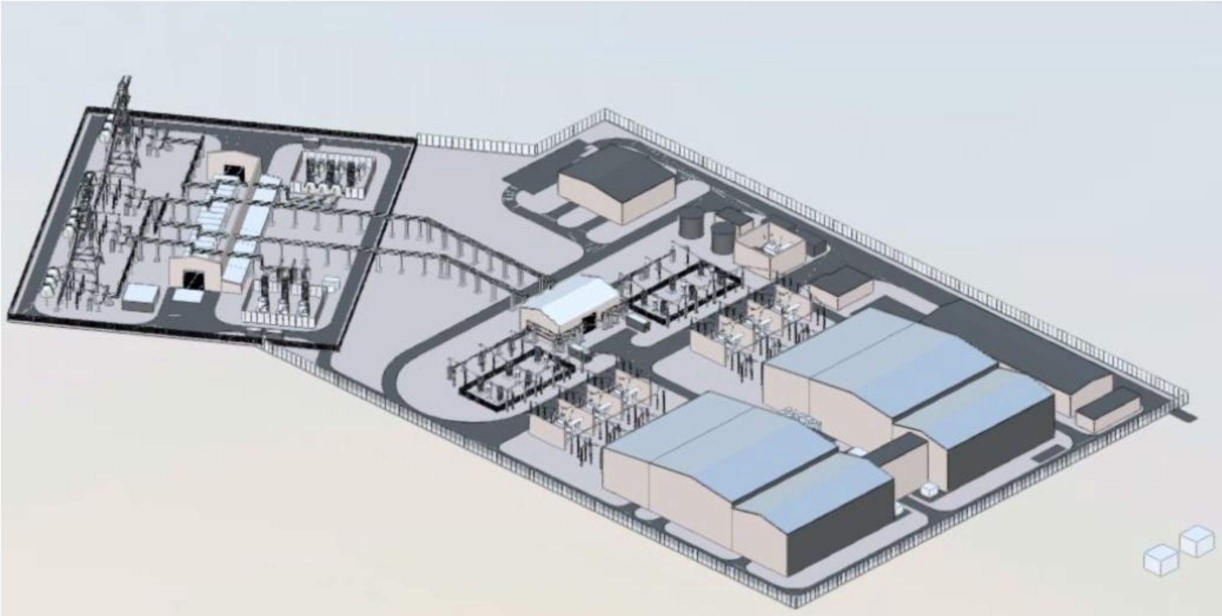


Plate 4.2 Indicative 3D view of the proposed Minster Converter Station and substation

4.3.10 Permanent access to Minster 400 kV substation and Minster Converter Station is via a new access point off the A256, north of Jutes Lane bellmouth K-BM02. This is illustrated on **Application Document 2.6.2 Traffic and Regulation Order Plans – Kent**.

4.3.11 The runoff from the permeable areas of the proposed Minster Converter Station site would percolate through to the groundwater table or emerge as pluvial runoff in a similar manner to the existing site. The runoff from the non-permeable areas of the converter station site (buildings, internal roads, car parks and external access roads) would discharge into two proposed permanent attenuation ponds which would ultimately outfall to existing watercourses as shown in **Application Document 2.14.2 General Arrangement Plans - Kent**.

4.3.12 A permanent water supply would be connected to the proposed Minster Converter Station and Substation to support operational needs, including welfare. Where supplies are not suitable for hydrant systems a trickle feed water tank would be provided to supply water for firefighting purposes.

4.3.13 Landscape proposals at Saxmundham Converter station are shown in **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan - Kent**.

Design

4.3.14 The architectural design of the proposed Minster Converter Station and Substation may vary within the physical parameters and LoDs set out above. The design of these structures, in terms of the building form and the external materials, has been developed alongside consultation and stakeholder feedback, including engagement with Design Review Panel. Design principles for the buildings have been developed and are provided with the application for development consent (**Application Document 7.12.2 Design Principles – Kent Tables 3.1 and 4.1**). These provide guidance regarding the design intent and principles that would be adopted and embedded into the detail proposals of this structure. The approach to design is also covered within **Application Document 7.11.2 Design Approach Document – Kent**.

Lighting

4.3.15 The external lighting system at Minster 400 kV substation and Minster Converter Station would meet the requirements of National Grid TS 2.10.04 Issue 1- 2017. This specifies that the minimum exterior lighting requirements are as follows.

- Maintained average illuminance: 6.0 lux.
- Maintained minimum point Illuminance: 2.5 lux.

4.3.16 The external lighting would allow the safe movement of vehicles and pedestrians between any two points that they may reasonably be expected to negotiate during the hours of low light or darkness within the site perimeter. The external lighting is not intended to facilitate maintenance activities for which it is assumed that additional portable equipment would be employed. Luminaires would be LED type fittings.

4.3.17 Road and site lighting would be provided using Road Lanterns and Floodlights. Wherever possible, road lantern and floodlight type luminaires would be mounted upon dedicated 8 m, galvanised steel, base-hinged columns designed to be lowered for maintenance purposes. Building mounted luminaires would provide amenity lighting to footpaths throughout the site.

Limits of Deviation

4.3.18 The lateral LoD is illustrated on **Application Document 2.5.2 Works Plans - Kent**. The extent of the lateral LoD allows for the necessary flexibility for the design process to continue to develop so that the most suitable position for the Minster 400 kV substation and Minster Converter Station can be delivered. The shape and arrangement of the converter and substation compound may vary within the LoD however a combined footprint would not be greater than the 90,610 m^2.

4.3.19 The vertical LoD for the proposed Minster 400 kV substation is 20 m above existing ground level as illustrated in **DCO/K/DE/SS/1252** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings - Kent**). The vertical LoD for the proposed Minster Converter Station is 28 m above existing ground level excluding lightning protection, aerials, walkways, fall arrest equipment and potential architectural treatments (such as soft landscaping) as illustrated in **DCO/K/DE/SS/1253** and **DCO/K/DE/SS/1254** of the Design and Layout Drawings (**Application Document 2.13.2 Design Drawings – Kent**). Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Proposed Underground HVDC Cables

4.3.20 The proposed underground HVDC cables would be routed from the proposed Minster Converter Station to the Kent landfall. From the proposed Minster Converter Station, the HVDC cables would be routed east to the north of Richborough Energy Park and the sewage works crossing the A256 to a TJB located to the west of St Augustine's and Stonelees Golf Club.

4.3.21 A typical HVDC construction swathe is illustrated on **DCO/S/DE/SS/1209** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**) and a typical HVDC joint bay arrangement is illustrated on **DCO/T/DE/SS/1301** of the Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**).

4.3.22 Table 4.8 provides a summary of the typical characteristics of the HVDC underground cables.

Table 4.8 Typical characteristics of HVDC underground cables

Characteristic	Proposed Project Indicative Description
Working width	Typically 40 m
Permanent easement	Typically 40 m
No of HVDC cables	Up to two
No of trenches	Up to one
Total length of HVDC cable route	2 km
Trench width	Typically 2.3 m
Trench depth	Typically 1.5 m
Number of ducts	Three (two cables and one fibre)
Minimum depth of cover	Agricultural land – typically 0.9 m (900 mm) Watercourses – typically 0.9 m (900 mm) varies per type of watercourse and owner Roads – typically 0.75 m (750 mm) Railways – typically 1.4 m (1400 mm) Footpaths and non-agricultural verges – typically 0.9m (900 mm)
Backfill material	Soil and CBS or other thermally suitable material. Typically, all topsoil would be retained and used during reinstatement. Where suitable sub soil is retained and used to backfill the trenches above the duct and CBS installation. As the installation of the ducts and CBS surround would typically take up approximately half the volume of the sub soil excavated, there would be excess sub soil following reinstatement. Any excess sub soil would either be retained for use on site, such as for landscaping or removed from site.
Cable section length	Typical cable section length: 800 m–1200 m
Above ground infrastructure	There is no above ground infrastructure associated with the HVDC installation other than the terminations which would be located within the Minster Converter station.

Limits of Deviation

4.3.23 The lateral LoD is illustrated on **Application Document 2.5.2 Work Plans - Kent**. The minimum burial depths are detailed in Table 4.8. No lowest below ground vertical LoD has been specified, this is because to place a limit may unnecessarily restrict below ground works where there is little or no chance of likely significant effects resulting. For example, it may be necessary to undertake archaeological excavation, and to have placed a limit on the depth of such excavation works would be unnecessarily restrictive. A standard below ground LoD is not therefore proposed. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

Kent Landfall

4.3.24 This is the transition point from underground HVDC cable to marine HVDC cable. The proposed Kent landfall is located within Pegwell Bay to the south of the settlement of Cliffsend. The proposed TJB would be located to the west of St Augustine’s and Stoneslees Golf Club and the Kent marine HVDC cables would cross St Augustine’s Golf course, Sandwich Road, Thanet Coast and Sandwich Bay SPA and Ramsar, Sandwich Bay Special Area of Conservation (SAC), Sandwich Bay to Hacklinge Marshes SSSI and Sandwich and Pegwell Bay National Nature Reserve (NNR).

4.3.25 The indicative location of the TJB is illustrated on **Application Document 2.14.2 General Arrangements Plans - Kent**. Whilst the location of the TJB is indicative within the LoD there is a commitment to make landfall using a trenchless crossing technique beneath the saltmarsh habitat within the Pegwell Bay. The location of the TJB and the exit of the trenchless crossing seaward of the mean highwater springs (MHWS) mark would be located outside of the sensitive saltmarsh habitat.

4.3.26 Four ducts would be installed. This is one more duct than is required for the terrestrial HVDC underground cables. Should a section of cable need to be replaced at the landfall, this additional duct would allow for a new section of cable to be pulled through rather than a repair to the existing or needing to re install ducts.

Limits of Deviation

4.3.27 The lateral LoD is illustrated on **Application Document 2.5.2 Works Plans - Kent**. No lowest below ground vertical LoD has been specified. Whilst a standard below ground LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

4.4 Offshore Scheme

4.4.1 The Offshore Scheme boundary is illustrated on **Application Document 2.2.1 Overall Location Plan**.

4.4.2 The proposed bundled marine HVDC cables would be routed from the TJB at the Suffolk landfall located at Aldeburgh and the TJB at the Kent landfall at located within Pegwell Bay to the south of the settlement of Cliffsend.

4.4.44.4.3 The marine HVDC cables would be routed south from the Suffolk landfall through a section of the Outer Thames Estuary SPA and to the west of the existing Greater Gabbard and Galloper offshore wind farms. They head east through the Sunk Traffic Separation Scheme (TSS) turning south to route around Margate and Long Sands SAC and between a number of mineral aggregate sites. The marine HVDC cables would then continue south to the east of London Array offshore wind farm and west of Thanet offshore windfarm before turning west to make landfall in Pegwell Bay.

4.4.54.4.4 The Offshore Scheme includes three distinct components, which are summarised below:

- Suffolk landfall: This is the area where the cable route transitions between the marine and terrestrial environment in Suffolk. This is located between the settlements of Aldeburgh and Thorpeness (further detail provided under Suffolk Landfall section above);
- Marine HVDC cable route: This is the cable route from the TJB at the landfall in Suffolk to the TJB at the landfall in Kent. The marine HVDC cable route is up to 122 km in length; and
- Kent landfall: this is the area where the cable route transitions between the marine and terrestrial environment in Kent, located in the Pegwell Bay area to the south of the settlement of Cliffs End (further detail provided under Kent Landfall section above).

4.4.64.4.5 Table 4.9 provides a summary of the Offshore Scheme characteristics.

Table 4.9 Offshore Scheme characteristics

Characteristic	Proposed Project Indicative Description
Number of HVDC cables	Two (one bundled pair)
HVDC cable diameter	100 mm to 150 mm
Number of fibre optic cables	One (bundled)
Fibre optic cable diameter	10 mm to 15 mm
Number of HVDC joints	Up to two
Number of Fibre Optic joints	Up to one
Transmission Capacity	2 GW
Operating Voltage	525 kV
Number of cable trenches	One for main offshore route
Offshore Trench Width	Trench width along the offshore route would be dependent on final engineered cable/bundle dimensions as well as the trenching methodology and sediment type, but would be in the range of 0.3 m–1.2 m.
Cable separation distances	0 m – bundled cable. Exception is separation at exit points where separation may range from 10 m to 40 m.

Characteristic	Proposed Project Indicative Description
Suffolk landfall	Four ducts (one per cable and one spare).
Kent landfall	Four ducts (one per cable and one spare).

Cable configuration

4.4.74.4.6 The cable configuration for the Offshore Scheme is assumed to be two HVDC cables and one fibre optic cable bundled together in one trench. With a bundled approach, the two cables and the fibre optic cable would be combined into a single bundle as shown in **Application Document 2.13.4 Design Drawings – Offshore**.

Limits of Deviation

4.4.84.4.7 The lateral LoD is illustrated on **Application Document 2.5.3 Work Plans – Offshore**. No lowest below seabed vertical LoD has been specified. Whilst a standard below seabed LoD is not proposed, the Proposed Project would never go deeper than necessary for technical or environmental reasons as this would add engineering operational complexity and cost.

4.5 Environmental Mitigation

4.5.1 The above sections describing the Suffolk Onshore Scheme, Kent Onshore Scheme and Offshore Scheme reference particular environmental mitigation measures which form part of the Proposed Project, where relevant. **Application Document 7.5.3.2 CEMP Appendix B Register of Environmental Actions and Commitments (REAC)** provides a full list of embedded measures, control and management measures and additional mitigation measures. As set out in **Application Document 6.2.1.5 Part 1 Introduction Chapter 5 EIA Approach and Methodology**, each technical topic chapter of the ES also outlines the proposed embedded measures, control and management measures and additional mitigation measures relevant to their assessment that are required to address likely significant effects of the Proposed Project. For instance, details of mitigation land identified within the Order Limits to mitigate likely significant effects for ecology and biodiversity can be found within the Additional Mitigation Measures section of **Application Document 6.2.2.2 Part 2 Suffolk Chapter 2 Ecology and Biodiversity** and **Application Document 6.2.3.2 Part 3 Kent Chapter 2 Ecology and Biodiversity**, as well as **Application Document 7.5.7.1 Outline Landscape and Ecological Management Plan – Suffolk** and **Application Document 7.5.7.2 Outline Landscape and Ecological Management Plan – Kent**.

4.6 Construction

4.6.1 This section describes how the infrastructure described above would typically be constructed and installed. An outline Onshore Construction Environmental Management Plan (CEMP) (**Application Document 7.5.3 Outline Onshore Construction Environmental Management Plan**) and Offshore CEMP (**Application Document 7.5.2 Outline Offshore Construction Environmental Management Plan**) have been produced. This includes an outline Code of Construction Practice (CoCP) (**Application Document 7.5.3.1 CEMP Appendix A Outline Code of Construction Practice**). The technical chapters within the ES Parts 2-5 have taken account of the control and management measures which are set out in the outline CoCP when undertaking their assessments. **Application Document 7.10 Coordination Document** sets out the proposed approach to coordinating construction of the Proposed Project with two potential National Grid Ventures (NGV) projects.

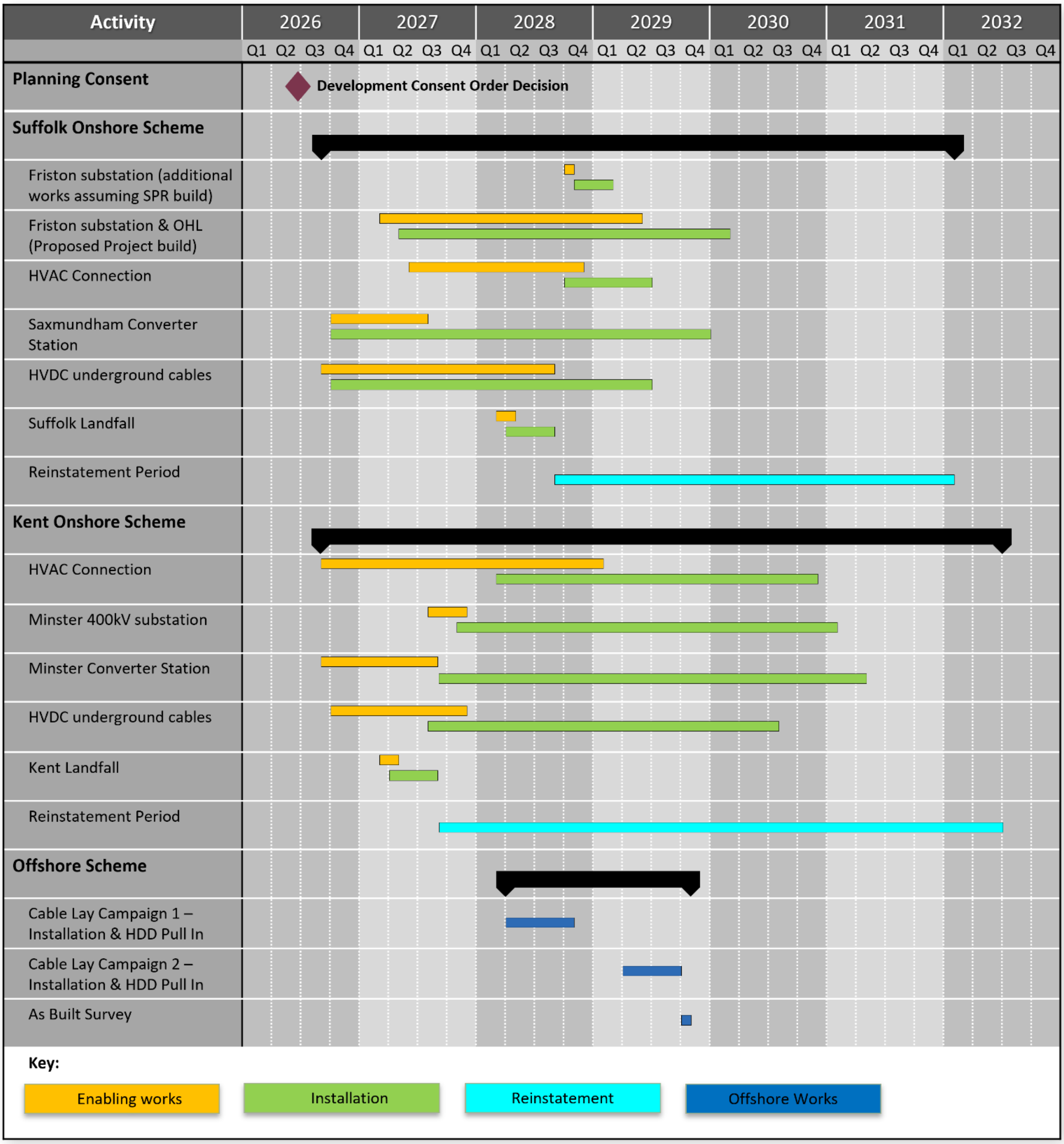
Construction Programme

4.6.2 Subject to gaining development consent, construction works would be expected to start in 2026 and be functionally completed by the end of 2031 with reinstatement potentially continuing into 2032. Certain advance works (such as archaeological trial trenching or protected species mitigation) may take place in advance of the main construction period.

4.6.3 The construction schedule would be developed as the Proposed Project progresses and would take account of seasonal constraints such as protected species breeding or hibernation seasons and reducing impacts associated with flood zones.

4.6.4 An indicative construction programme for the Proposed Project is presented in Table 4.10.

Table 4.10 Indicative construction programme



Construction Workforce

4.6.5 The staff required during the construction of the proposed works would vary throughout time. It is anticipated that the peak workforce for the Suffolk Onshore Scheme would be approximately 327 which is expected to peak indicatively in 2028. The peak workforce in Kent would be approximately 241 which is anticipated to occur indicatively in 2030. The peak Offshore Scheme workforce is expected to be approximately 275 indicatively in 2028 and continuing into 2029.

Construction Working Hours

4.6.6 The proposed construction core working hours (unless otherwise approved by the relevant Local Planning Authority) for all terrestrial works in Kent and Suffolk are:

- Monday – Friday: 0700 to 1900; and
- Saturday, Sundays and Bank Holidays: 0700 to 1700.

4.6.7 The core working hours exclude start up and close down activities up to one hour either side of the core working hours. These activities include staff arrival, briefings, checking plant, loading equipment, compound general maintenance activities, debriefing, storing equipment and plant, and staff leaving site.

4.6.8 Exceptions to the above core working hours include but are not limited to:

- trenchless crossing operations including at landfalls and beneath highways, railway lines, woodlands, nature reserves, SSSI or watercourses;
- the installation and removal of conductors, pilot wires and associated protective netting across highways, railway lines or watercourses;
- the jointing of underground cables;
- the continuation of any work activity commenced during the core working hours to a point where they can securely and or safely be paused;
- delivery to the transmission works of abnormal loads and any highway works requested by the highway authority to be undertaken outside the core working hours;
- the testing or commissioning of any electrical plant installed as part of the authorised development including undertaking of any identified corrective activities;
- the completion of works delayed or held up by severe weather conditions which disrupted or interrupted normal construction activities;
- activity necessary in the instance of an emergency where there is a risk to persons or property;
- marine works (all works below the mean high water springs line);
- security monitoring;
- intrusive and non-intrusive surveys; and
- mechanical and electrical installation works within buildings once erected and enclosed;
- any highway works requested by the highway authority to be undertaken on a Saturday or Sunday or outside the core working hours; and
- activity necessary in the instance of an emergency where there is a risk to persons or property.

4.6.9 Percussive pilling works would be limited to Monday – Friday: 0700 to 1900 and 0700 to 1700 on Saturdays and may not occur on Bank Holidays, unless otherwise approved by the local planning authority.

~~4.6.11~~4.6.10 Subject to the exceptions listed in paragraph 4.6.9 above, Heavy Goods Vehicles (HGV) deliveries would be limited to Monday – Friday: 0700 to 1900 and 0700 to 1700 on Saturdays and may not occur on Bank Holidays, unless otherwise approved by the relevant highway authority.

~~4.6.12~~4.6.11 For the marine cable, construction would be a 24 hour operation where viable to minimise overall installation time, maximise the use of suitable weather windows and take advantage of vessel and equipment availability.

Terrestrial Enabling Works, Access, and Site Preparation

~~4.6.13~~4.6.12 In order for the elements of the Suffolk and Kent Onshore Schemes to be constructed, enabling works are required such as the establishment of construction compounds, temporary bellmouths and access tracks and drainage works. The enabling works are consistent across all elements of the Onshore Schemes and have therefore been described once below rather than for each individual element.

Enabling works and earthworks

~~4.6.14~~4.6.13 Construction would commence with site establishment, involving demarcation of the site, stripping of topsoil and erection of temporary facilities, i.e. site offices, storage areas and hardstands. Bellmouths and access roads would also be constructed at this stage to ensure prior access from the highway network for construction traffic. See sections below for detail on construction of haul roads and bellmouths. The construction traffic routes for the terrestrial works are illustrated in **Application Document 6.4.1.4.7 Suffolk Onshore Scheme Traffic Routes during Construction and Operation** and **Application Document 6.4.1.4.8 Kent Onshore Scheme Traffic Routes during Construction and Operation**.

~~4.6.15~~4.6.14 Earthworks would begin upon completion of site establishment, involving levelling of the site and creation of the platform to the necessary levels according to the topography and to facilitate drainage. Landscaping involving earth bunds may also be completed at this stage to reduce the visual impact of the completed compound.

~~4.6.16~~4.6.15 In Suffolk it is anticipated that suitable bearing pressure would be available at formation level without a significant ground improvement layer being required. It is considered likely that shallow pad and or strip foundations can be used although if very strict settlement tolerances are required with high loads, then piling may be necessary. Detailed assessment of stiffness properties at the detailed design stage would inform the most suitable foundation solution.

~~4.6.17~~4.6.16 In Suffolk, the construction of the converter station would require an estimated 42,000 m^3 of cut to create the level formation, cut into the slope to lower the site. Approximately 24,400 m^3 of fill would be required for the platform structure made up of Type 3 material and chippings.

~~4.6.18~~4.6.17 In Kent ground improvement would be required and this is likely to involve the excavation and replacement of soft ground. A minimum of 400 mm would be excavated, plus soft spots highlighted through in-situ testing, a geotextile separator would be laid and then fill using imported material to a depth of 0.8 m-1.0 m would be required to form the formation level for future construction works. The compound surfacing and any shallow foundations and cable troughs would be built up from this level, noting that larger load foundation would likely need to be piled. Once initial earthworks have been completed, all drainage should be installed to prevent any waterlogging during the construction stage.

~~4.6.19~~4.6.18 In Kent, the Minster 400 kV substation and Minster Converter Station would require approximately 250,000 m^3 of fill and approximately 40,000 m^3 of cut, to create a platform on which the structures would be built.

Temporary construction compounds

~~4.6.20~~4.6.19 Temporary construction compounds would be established at the converter station and substation sites as well as along the HVDC and HVAC underground cable and overhead line routes to facilitate construction activities.

~~4.6.21~~4.6.20 These compounds store all materials necessary for the works, including plant, waste, cable ducts, cable drums and accessories. In addition to storage, compounds also provide a location for site offices, parking and welfare facilities for construction operatives.

~~4.6.22~~4.6.21 The indicative location of the construction compounds for the Suffolk Onshore Scheme are illustrated on **Application Document 2.14.1 General Arrangement Plans - Suffolk**. In Suffolk, construction compounds are proposed adjacent to the B1121 bellmouth (construction compound S01), proposed Saxmundham Converter Station site (construction compounds S02, S03, S04 and S05), proposed Friston Substation site (construction compounds S06 and S07), along the proposed HVDC cable route (construction compounds S08 and S09) and proposed landfall site (construction compound S10). It should be noted that not all of the construction compounds S02, S03, S04 and S05 would be required for the Proposed Project's Saxmundham Converter Station site, but either S02, or S03, or a combination of both S04 and S05 would be used. This flexibility is included to provide flexibility for NGV to locate their own converter station and construction compound for the proposed LionLink (formerly known as EuroLink) and Nautilus projects within this area (see **Application Document 7.10 Coordination Document** for further details of the coordination being undertaken).

~~4.6.23~~4.6.22 The indicative locations of the construction compounds for the Kent Onshore Scheme are illustrated on **Application Document 2.14.2 General Arrangement Plans - Kent**. In Kent, construction compounds are proposed adjacent to the combined converter station and substation site (construction compounds K01, K02 and K03), A256 bellmouth (construction compounds K04 and K05), and near the landfall site (construction compound K06). The construction compound at K05 may not be required in the field to the east of the A256 if the offshore cable were to be taken further inland (in that scenario only K04 to the west of the A256 would be required) depending on the final design. However, the worst-case of a compound also being required east of the A256 is assessed in this Environmental Impact Assessment (EIA).

~~4.6.24~~4.6.23 The proposed footprint of the compounds varies depending on the compounds use and section of the route served. A typical layout plan of a converter station and substation construction compounds is illustrated on **DCO/T/DE/SS/1303** of the Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**). A typical layout plan of a combined cable and converter station construction compound is illustrated on **DCO/T/DE/SS/1305** of the Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**). A typical cable or overhead line (OHL) compound is illustrated on **DCO/T/DE/SS/1302** of the Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**).

4.6.264.6.24 Construction begins by securely fencing the site and removing / storing topsoil in bunds adjacent to the site. Where stripping of the top soil has occurred, the compound area is excavated to the required formation level and the associated material either stored in the same manner or removed offsite. The formation level is determined by the pavement thickness applicable to the individual ground conditions at each location. Where existing ground conditions are poor, the pavement layer would be thicker, and consequently a greater volume of excavation required or the compound would be raised above the existing ground level.

4.6.274.6.25 Once excavation has been completed, a geomembrane separation layer and a geotextile reinforcement layer (often as a combined composite layer) would be laid, followed by compacted layers of stone in the same manner as the haul road construction. The majority of the compound would be left as natural stone, however, car parks may be surfaced with a bituminous surface layer to prevent damage to road going vehicles, such as cars and vans. Alternatively, soil stabilisation may be employed, where the existing ground is chemically strengthened allowing the volume of imported stone to be reduced. Soil stabilisation is normally undertaken by specialist contractors, with the stabilisation reversed following completion of the works.

4.6.284.6.26 Lighting, gates and additional security measures would be provided, for the safety of operatives and to improve site security.

4.6.294.6.27 The drainage for the construction compounds comprises of sustainable drainage systems (SuDs) that would attenuate runoff levels to green field runoff rates in line with the requirements of the receiving watercourse authorities (Internal Drainage Board, Environment Agency or Lead Local Flood Authority (LLFA)). The drainage strategy uses a combination of storage within the compound materials and attenuation ponds to achieve the attenuation required, alternative methods including swales or buried storage tanks could be used. The drainage would be constructed at the same time as the formation platform of the construction compound. Perimeter swales around the formation platform would be installed by the contractor and connected to the attenuation ponds or similar to drain all runoff. The drainage during the construction stage would be considered as "dirty water" due to the possibility of contamination with oils and silts. The design would include pollution controls and the contractor would implement suitable mitigation measures to manage this risk during construction. A settling pond or vegetated forebay within the attenuation pond should be included to trap sediments before discharging the water into the nearest watercourse. All settlement ponds would be provided with oil absorbents to absorb any hydrocarbons accumulated.

4.6.304.6.28 In Suffolk, the construction compound drainage systems would be designed to accommodate a 1 in 100-year return period storm event. In Kent, the construction compound drainage systems would be designed to accommodate a 1 in 30-year return period storm event. This is in line with guidance nationally and from the relevant local planning authorities for enabling works.

4.6.314.6.29 To prevent runoff entering the site from the adjacent ground and creating additional polluted waste, installation of filter drains/swales along the perimeter of the construction compound would be required to intercept these "clean" flows that would discharge into the nearest watercourse. Compounds could implement water conservation measures by the following:

- Water from settlement ponds can be pumped into a bowser and used to dampen haul roads and site compounds to prevent the generation of dust.

- Vehicle washing should only be used in a bunded area where the runoff can be contained and channelled into a treatment area, such as a settlement pond, prior to discharge.

~~4.6.32~~4.6.30 Storage areas within a construction compound should sit away from sensitive receptors, at least 10 m from a watercourse or a drain.

~~4.6.33~~4.6.31 Temporary construction compounds would be connected to water supplies where reasonable connections can be made to support welfare facilities. If reasonable connections are not available, then water would be tankered to the construction compound. Water for construction activities such as concrete batching or trenchless drilling would be tankered to the construction compound. The location of tankered supplies would be agreed with the relevant authorities once a contractor supplier has been appointed for the Proposed Project.

Utility interfaces

~~4.6.34~~4.6.32 The Proposed Project would require diversions of utility assets, such as 132 kV infrastructure and telecommunications cables. Depending on the type of asset and required interaction during the construction works, various types of solution are required, such as installing provisions to protect the asset or diverting the asset to avoid interference.

~~4.6.35~~4.6.33 Where diversions to existing assets are required, these would be undertaken by the asset owner in advance of any construction works commencing for the Proposed Project. The asset owners would be able to do so using their own statutory rights, however, the rights are also sought under the Development Consent Order (DCO) for the Proposed Project to grant National Grid powers to undertake these works.

~~4.6.36~~4.6.34 The proposed construction works would require connections to the existing Distribution Network Operator system to provide a supply to the new sites in Suffolk and Kent, both temporarily during construction and permanently for operation.

~~4.6.37~~4.6.35 In Suffolk, there would be 64 utility interfaces requiring provisions and 15 utility diversions along the route. All 15 utility diversions relate to assets owned by UK Power Networks. These diversion routes are illustrated in **Application Document 2.14.1 General Arrangements Plans – Suffolk.**

~~4.6.38~~4.6.36 In Kent, there would be 47 utility interfaces requiring provisions and four utility diversions along the route. All four utility diversions relate to assets owned by UK Power Networks. These diversion routes are illustrated in **Application Document 2.14.2 General Arrangements Plans – Kent**.

Public Rights of Way

~~4.6.39~~4.6.37 The Proposed Project would cross the existing Public Rights of Way (PRoW) network. The works which would be required at these locations can be classified into four categories. These are:

- Provisions – at these locations a diversion would not be required. However, safety measures would be put in place to maintain access during the construction period. The installation of safety measures is likely to require short term closures or the control of users using stop go boards or similar, to allow for the installation of fences, gates or overhead netting as required.

- Long term temporary diversion – at these locations a diversion route would be provided for the duration of the construction works.
- Short term temporary diversion – at these locations, the impact on the PRoW is caused by isolated construction activities, so a diversion would only be required for a reduced period of time. These diversions would be implemented within the Order Limits locally to the PRoW affected. For example during the installation of haul roads or ducts across the PRoW, the route would be temporarily diverted 50-100 m along the alignment of the Order Limits to cross a section already installed or an area not yet reached by the works.
- Permanent diversion – at these locations the route of the existing PRoW would be impacted by the permanent assets. A permanent diversion route would therefore be required.

~~4.6.40~~4.6.38 In Suffolk, there are 21 locations where the proposed works would impact the existing PRoW network identified in **Application Document 6.3.1.4.A Appendix 1.4.A Crossing Schedules** and presented in **Application Document 6.4.1.4.5 PRoW, Highway and Railway Crossings**.

~~4.6.41~~4.6.39 In Kent, there are 16 locations where the proposed works would impact the existing PRoW network identified in **Application Document 6.3.1.4.A Appendix 1.4.A Crossing Schedules** and presented in **Application Document 6.4.1.4.5 PRoW, Highway and Railway Crossings**.

Haul roads

~~4.6.42~~4.6.40 Construction haul roads are required to facilitate access and construction of the cable route, substations and converter stations, and to provide a stable platform on which to store or manoeuvre materials. There are a number of different options available including temporary track way, stone roads and soil stabilisation.

~~4.6.43~~4.6.41 Track way is often more efficient where limited access is required over a relatively short duration, whereas stone roads typically provide a more effective solution for heavily trafficked areas required for longer durations. Soil stabilisation can be used to give a similar performance to a stone road, by chemically strengthening the existing soils and is often used in combination with stone to provide a more sustainable and reliable solution.

~~4.6.44~~4.6.42 The haul road width is typically 7 m, to allow for passing vehicles, although this may extend in limited areas to provide turning for HGVs and construction plant.

~~4.6.45~~4.6.43 In Suffolk, due to anticipated ground conditions it is currently expected that the haul road would be stone but could potentially utilise soil stabilisation.

~~4.6.46~~4.6.44 In Kent, due to anticipated ground conditions and predicted volume of traffic it is currently expected that the section of haul road to the west of the level crossing would utilise track way and to the east would utilise stone. The haul road for the combined converter station and substation area is expected to be stone as this would eventually be used for the permanent access to the site (with the addition of a bituminous surface on top of the stone sub-base).

~~4.6.47~~4.6.45 The contractor would ultimately choose the solution that best fits the needs of the works and conditions encountered on-site during construction. However, a reasonable worst case scenario has been assessed within this ES.

~~4.6.48~~4.6.46 Stone haul roads would be constructed of an unbound stone material bedded on a separation membrane and polymer based geogrid reinforcement. The separation membrane serves to prevent ingress into the underlying ground (subgrade) and to aid removal upon completion of the works. The reinforcement layer provides additional mechanical stability, significantly reducing the overall road (pavement) thickness and the associated volume of imported material required.

~~4.6.49~~4.6.47 Topsoil is first stripped, exposing the underlying ground (subgrade), and is stored adjacent to the works, this helps to protect the top soil during the construction period. The exposed ground is then excavated to the required formation level and tested for strength. Where soft grounds are encountered, further excavation would be undertaken until a stable subgrade is reached.

~~4.6.50~~4.6.48 The ultimate thickness of the haul road is determined by the subgrade strength, vehicle type and vehicle numbers. A soft subgrade would dictate a thicker construction than a stronger subgrade.

~~4.6.51~~4.6.49 Once excavation has been completed and a suitable subgrade determined, a geotextile separation membrane is placed onto the subgrade, followed by the geogrid reinforcement. These are overlain by a layer of stone, placed and compacted in layers, up to the required thickness and/or finished surface level. Two layers of different stone types may be used if the design dictates (capping and subbase design).

~~4.6.52~~4.6.50 The haul roads are generally assumed to be installed at existing ground level. Perpendicular cross drains may also be installed beneath the haul road to allow water to flow across the road. In order to prevent overland greenfield flows from crossing the haul road, header drains would be installed along the scheme to intercept clean surface water runoff and prevent the haul road from becoming silty. The header drains would run parallel to the haul roads and discharge into the nearest watercourse along the route.

~~4.6.53~~4.6.51 Filter drains or swales are used on either side of the haul road. They collect runoff from the haul road and discharge into various “dirty water” ponds (which include a settlement pond for the construction phase, to remove silts from the water prior to discharging into an existing watercourse) along the route.

Bellmouths

~~4.6.54~~4.6.52 Construction of the bellmouths would follow the same method as described above for stone haul roads. Sizing of the bellmouths would be in accordance with the relevant design guidance and the vehicles required to access/egress the site. Visibility requirements would dictate where the bellmouths can be positioned. Normally, traffic management measures and/or a reduced speed limits are required to safely manage the interaction between works traffic and the public highway at bellmouths, particularly where visibility may be limited. It is sometimes necessary to alter or upgrade elements of the public highway for similar reasons (**Application Document 2.13.3 Design Drawings – Terrestrial General**).

~~4.6.55~~4.6.53 Following top-soil stripping, the subbase would be compacted in layers prior to the running surface being laid. To provide better longevity from turning vehicles, particularly articulated HGVs, the finished surface would normally be constructed of a bituminous material or concrete. Pavement material may be removed at the interface between the existing highway in order to join the two constructions and prevent degradation during use. Road signs, site demarcation and linework would be installed in accordance with the relevant highway design to provide a safe environment for road users and construction traffic. Finally, fencing is erected surrounding the site and gates installed, setback approximately 15-20 m from the highway to allow vehicles to stop clear of passing traffic.

~~4.6.56~~4.6.54 Filter drains or swales are used on either side of the bellmouths and they are linked to the network of filter drains or swales that form the haul road drainage.

~~4.6.57~~4.6.55 The Suffolk Onshore Scheme would be predominantly accessed via the following three bellmouths during the construction phase (as shown on **Application Document 6.4.2.7.2 HGV Routing Plan**):

- **B1069 Eastern Side (S-BM03)**: Access to the area to the east of the B1069, including for cable installation, building the Joint Bay shed, cable jointing and joint bays. To be used throughout the construction programme, peak activity at this access is expected to occur in 2028.
- **B1069 Western Side (S-BM04)**: Access to the area to the west of the B1069, including for access works, utility crossings, haul road and compound installation, access to Friston substation (for installation), cable jointing, testing, demobilisation and reinstatement. To be used throughout the construction programme, peak activity at this access is expected to occur in 2027.
- **B1121 Main Road (S-BM09)**: Access to Saxmundham Converter Station for preparation works, haul road and compound installation, bridge and converter station installation, demobilisation and reinstatement. To be used throughout the construction programme, peak activity at this access is expected to occur in 2027.

~~4.6.58~~4.6.56 A small proportion of construction vehicles (circa 3% in total) is expected to use the remaining access points which comprise S-BM01 and S-BM02 (B1122 Leiston Road), S-BM11 (B1121 Saxmundham Road), S-BM10 (A1094 Aldeburgh Road), S-BM12 (B1119 Church Street) and S-BM13 (Thorpe Road). The accesses on Grove Road (S-BM05 and S-BM06) would be used as a vehicle crossover only and no vehicles would therefore turn to/from Grove Road to use these access points.

~~4.6.59~~4.6.57 The new permanent access point for Saxmundham Converter Station would be via S-BM09 off the B1121 Main Road in the instance that this access is retained after construction. A further point of access would be taken from the B1119 to the northeast (S-BM14 or S-BM15) to access Saxmundham Converter Station, however this would only be for monitoring purposes during the operational phase. The new permanent access point for Friston Substation would be via S-BM07 on the B1121 Saxmundham Road. A permanent access would also be provided on the southern side of the A1094 Aldeburgh Road (S-BM16) for monitoring purposes.

~~4.6.60~~4.6.58 In addition, four existing accesses would be used to access areas of the site for specific works, these are the access to Hazelwood Hall Farm off the A1094, the access to Wood Farm of the B1119, field access off Redbarn Lane and foreshore access via the unofficial parking area on Thorpe Road. Proposed access routes are shown in **Application Document 2.7.1 Access, Rights of Way and Public Rights of Navigation Plans – Suffolk**.

4.6.614.6.59 The Kent Onshore Scheme would be predominantly accessed via the following four bellmouths during the construction phase (as shown on **Application Document 6.4.3.7.2 HGV Routing Plan**):

- **A256 Northbound Carriageway (K-BM02)**: Main access during both construction (for mobilisation/trenchless work and the haul road to the west of the A256) and operation (permanent access/field access) – to be used throughout the construction programme accommodating circa 91% of all construction vehicle trips (circa five years, peak year in terms of total annual movements expected in 2030, with a daily peak in 2028).
- **Ebbsfleet Lane (K-BM01)**: Access during both construction (for the haul road, compound, storage of materials and HDD location to the east of the A256) and operation (permanent field access) – to be used for approximately ten months during construction (prior to 2030 peak) accommodating circa 4% of all construction vehicle trips.
- **Ebbsfleet Lane North (K-BM06)**: Secondary access during construction for vegetation clearance works, utility diversion works for the OHL, survey works, and limited mobilisation movements associated with the construction of the A256 access – to be used for approximately six months during construction (prior to the 2030 peak) accommodating circa 2% of all construction vehicle trips.
- **Sandwich Road (K-BM07)**: Secondary access during construction to access a compound and facilitate foreshore works (via the existing Pegwell Road access track) for compound installation, soil stripping, haul road installation, compound stone and surfacing, and drainage, as well as for duct installation and cable installation – to be used for approximately six months during construction (prior to 2030 peak) accommodating circa 2% of all construction vehicle trips.

4.6.624.6.60 In addition to the above, a very small proportion of construction vehicles (circa 1% in total, and less than 1% HGVs) would use the following three access points:

- Jutes Lane (K-BM03): To be used for utility connection works.
- Marsh Farm Road (K-BM04): To be used to undertake temporary diversion works to the OHL, including constructing a temporary structure, realigning conductors and building scaffold protection towers. Vegetation clearance and survey works would also be undertaken at this access.
- Whitehouse Drove (K-BM05): To be used to access the bridge location to enable the construction of the southern abutments, this would require laying track way and constructing water course crossings (culverts). Vegetation clearance and survey works would also be undertaken at this access.

4.6.634.6.61 A new permanent access point for Minster Converter Station and Minster Substation would be via K-BM02 off the A256.

4.6.644.6.62 In addition, seven existing accesses would be used to access areas of the site for specific limited works activities, these are Marsh Farm Road, Ebbsfleet Lane (North), Cottington Road (Access into golf course), Sandwich Road (Access to the old hoverport), Jutes Lane, Whitehouse Drove and an existing track access off Richborough Road. Proposed access routes are shown in **Application Document 2.14.2 General Arrangement Plans – Kent**.

4.6.664.6.63 A typical bellmouth is illustrated on **DCO/T/DE/SS/1300** Design and Layout Drawings (**Application Document 2.13.3 Design Drawings – Terrestrial General**) and indicative bellmouth locations for Suffolk and Kent are shown on **Application Document 2.7.1 Access, Rights of Way and Public Rights of Navigation Plans – Suffolk**.

Temporary culverts

4.6.674.6.64 Temporary culverts would be required where the construction haul roads cross existing watercourses, i.e. ditches, field drains, dykes and small rivers. Culverts would be in place for the duration of the works and removed upon completion. Generally, these are limited to circa 3 m wide and extend to approximately 2 m beyond the width of the road. The type of culvert is dependent upon the size and the ecological and hydrological properties of the ditch. Typical types include concrete pipes, plastic (twinwall) pipes and pre-cast concrete modular units (box or portal culverts). Each have slightly varied and specific methods of installation, but the key stages are described below.

4.6.684.6.65 Following ecological surveys (and watching briefs, subject to requirements), the crossing location is firstly cleared of vegetation and any bankside furniture removed. Bunds are then installed upstream and downstream of the crossing location to prevent the ingress of water to the excavation. A series of pumps and pipes are then installed to transfer the flow of water from the upstream side to the downstream side, bypassing the worksite.

4.6.694.6.66 Once the worksite is sufficiently dewatered, the bed of the watercourse is excavated to the required depth. Generally, this is to a depth such that the pipe or culvert invert is at bed level once placed on the required thickness of bedding.

4.6.704.6.67 A geotextile separation membrane is placed into the excavated trench followed by bedding material, placed, and compacted to the required depth and gradient. The pipe or culvert sections are then lifted into the trench and jointed. Further material is placed around and above the pipe/culvert and compacted to a level required to provide adequate protection from traffic. A prefabricated concrete or concrete bag headwall and temporary fencing are subsequently installed around the culvert followed by the haul road construction. Upon completion, the temporary bunds and pumps are removed, allowing water to flow freely through the newly laid culvert sections.

4.6.714.6.68 Where a bridge structure or culvert is used as a haul road, mud and debris should not be allowed to build-up. Straw bales or sandbags should be placed along the haul road to prevent silty water running off into the water below.

4.6.724.6.69 In Suffolk, nine temporary culverts crossings would be required along the cable route's haul roads. Two permanent culverts would be required, one on each of the permanent roads to the proposed Saxmundham Converter Station and proposed Friston Substation and one permanent bridge over the River Fromus.

4.6.734.6.70 In Kent, due to the presence of numerous existing watercourses, 30 culvert crossings would be required (27 temporary and four permanent) along the haul roads plus one temporary bridge over the River Stour.

4.6.744.6.71 A watercourse crossing Schedule is provided at **Application Document 6.3.1.4.A Appendix 1.4.A Crossing Schedules** and presented in **Application Document 6.4.1.4.4 Watercourse Crossings**.

Bridges

~~4.6.75~~4.6.72 At main rivers, bridges would be required. These would be temporary or permanent depending on whether they are on the temporary haul road network or along one of the permanent accesses. Access to both sides of the bridge location would be required using mobilisation accesses to undertake vegetation clearance and foundation and abutment construction, the primary access would then be used to bring in elements of the bridge deck which would be lifted into place using a mobile crane. Proposed access routes are shown in **Application Document 2.14.1 General Arrangement Plans – Suffolk** and **Application Document 2.14.2 General Arrangement Plans – Kent**.

~~4.6.76~~4.6.73 As noted in paragraph 4.2.26, a bridge with either a 2 m or 4 m clearance (Option 1 and 2 respectively) from existing ground level to proposed soffit level would be required over the River Fromus in **DCO/S/DE/SS/1210** of the **Application Document 2.13.1 Design Drawings - Suffolk.** Table 4.4. provides the approximate dimensions of this proposed crossing structure for both options.

~~4.6.77~~4.6.74 In Kent a temporary bridge would be required over the River Stour similar to that used for the Richborough Connection Project.

Utilities and drainage

~~4.6.78~~4.6.75 Drainage works would be undertaken on the site, including diversions of existing watercourses, installation of new stormwater and foul water drainage, and construction of any interceptor tanks and/or attenuation/infiltration ponds.

~~4.6.79~~4.6.76 Third party utility connections would be completed to the site; water, foul, communications, and power, as required. Specific easements would be utilised for each of the assets within the converter station or substation boundary. Requirements for each asset would need to be agreed with each of the third-party utility providers, which would be determined at detailed design.

~~4.6.80~~4.6.77 All drainage for the proposed substations, converter stations and construction compounds would be installed at the initial stage of the construction phase to avoid any waterlogging during construction. Where groundwater is elevated, lining of the ponds with an impermeable liner may be necessary to mitigate groundwater ingress, and anchoring of the liner may be required to manage buoyancy. In Kent, ponds would be limited to 500 mm deep due to the high water table expected, the site would also be raised to allow for gravity drainage to be installed.

~~4.6.81~~4.6.78 The site earth mat would be installed at an early stage, with requirements set out based on the High Voltage (HV) Plant arrangement, electrical requirements, and local ground conditions of each site. The main earth grid is typically installed 500 mm below ground and is therefore installed at an early stage with earthworks and utility installation. Final earth mat connections would be completed once equipment has been installed on site.

Installation Works

Foundations

~~4.6.82~~4.6.79 Foundation requirements are location specific and dependent on the geology of the area and function of the foundation. The use of piling can be required due to the settlement criteria of the electrical equipment within high voltage converter stations and substations.

~~4.6.83~~4.6.80 The installation of foundations is typically completed in parallel to the utilities and drainage works due to the interfaces. Foundations supporting HV equipment may require significant ducting and fixings to be suitable for the HV equipment functions.

Structural construction

~~4.6.84~~4.6.81 Once the above works have been fully completed, erection of the converter halls and supporting buildings can begin. Buildings typically comprise of steel frames, craned into place, fixed and clad with composite materials.

~~4.6.85~~4.6.82 The materials and cladding used in converter station and substation environments are typically simplistic, utilising greys and greens to blend into the surroundings. Exact specifications vary dependent on location and stakeholder engagement and would be in line with the design principles and approach for the Proposed Project (see **Application Document 7.11.1 Design Approach Document – Suffolk**, **Application Document 7.11.2 Design Approach Document – Kent, Application Document 7.12.1 Design Principles – Suffolk Tables 3.1 and 4.1** and **Application Document 7.12.2 Design Principles – Kent Tables 3.1 and 4.1**.

Proposed Substations

~~4.6.86~~4.6.83 The typical construction sequence for the construction of a substation would involve:

- survey and ground investigations;
- set up of site establishment and temporary facilities;
- temporary access to the substation;
- earthworks;
- civil engineering works including cable works and drainage;
- building works;
- mechanical and electrical;
- outage works to disconnect the overhead line including temporary towers/masts where required;
- construction of new towers;
- outage to reconnect overhead line via new towers to substation;
- commissioning/energisation; and
- reinstatement

~~4.6.87~~4.6.84 For the purposes of the ES, it has been assumed that the construction of the proposed substations would take approximately three years, which is typical for a substation.

~~4.6.88~~4.6.85 As set out earlier in this Chapter, the proposed substation at Friston already benefits from development consent pursuant to 'The East Anglia ONE North Offshore Wind Farm Order 2022' and 'The East Anglia TWO Offshore Wind Farm Order 2022'.

The construction sequencing would likely be different depending on whether the substation was delivered by SPR pursuant to its development consent(s), or whether it was delivered by National Grid pursuant to the DCO for the Proposed Project.

4.6.894.6.86 Should the Proposed Project only need to extend the Friston substation rather than construct it in full then the construction sequence would include the following:

- civil engineering works including cable works;
- building works;
- mechanical and electrical;
- commissioning/energisation; and
- reinstatement.

Proposed Converter Stations

4.6.904.6.87 A typical construction sequence for the construction of a converter station following the enabling works would include:

- survey and ground investigations;
- installation of bellmouths and creation of visibility splays where required;
- access road construction;
- site establishment;
- ground improvement and earthworks including levelling or raising the site;
- civil engineering works including drainage;
- building works;
- cable installation;
- provision/installation of permanent services;
- mechanical and electrical works;
- commissioning; and
- site reinstatement and landscape works.

4.6.914.6.88 The construction of the proposed converter stations would take approximately four years from first site access to reinstatement, excluding ongoing landscaping monitoring or maintenance.

Mechanical and Electrical

4.6.924.6.89 Once the converter station and substation buildings have been completed these are then fitted with electrical equipment necessary to operate and administer the converter station. At the same time, the outdoor or indoor electrical equipment, including switchgear and busbars, would be fixed to the foundations and erected.

4.6.934.6.90 During the final stages of construction, high voltage transformers would be delivered to site and moved into place. These often weigh in excess of 300 tons and comprise an abnormal indivisible load (AIL). As a result, they are delivered on specialist equipment requiring movement permits and significant route planning and/or works.

Movement on site would be undertaken by high-capacity mobile cranes or through hydraulic jack skids.

4.6.944.6.91 In Kent the AILs are expected to arrive from the north requiring the temporary closure of the A256 northbound carriageway, during the movement the southbound carriageway would be run in contraflow conditions as shown in **Application Document 2.6.2 Traffic and Regulation Order Plans – Kent**.

4.6.954.6.92 In Suffolk there are two options for bring the AILs to the site, one is via the permanent access utilising the A12 and B1121 Main Road, this would require routing the AIL over a bridge (B1121 over rail near Benhall Green) that has a weight limit of 80 t, therefore further structural assessment and temporary works would be required. The temporary works would likely require the temporary bridging of the structure using metal girders and pad foundations temporarily installed over the structure, this would require the closure of the B1121 for an elongated period (anticipated up to a maximum of seven weeks). The alternative is to bring the AILs via Leiston and the Snape Road access and then along the haul road. Proposed AIL routes are shown in **Application Document 6.4.2.7.3 Abnormal Load Routing Plan** and **Application Document 6.4.3.7.3. Abnormal Load Routing Plan**.

Proposed Overhead HVAC Connection

4.6.964.6.93 The construction of a section of 400 kV overhead line would generally be sequenced as follows:

- Pre-construction:
  - surveys and ground investigations:
  - preparation of site facilities;
  - vegetation clearance via mobilisation accesses.
- Access, construction lay down areas:
  - installation of bellmouths and creation of visibility splays;
  - installation of access tracks (including culverts and bridges) and demarcated pylon working areas;
  - installation of stock proof fencing and gates or equivalent;
  - preparation of temporary lay down areas.
- Foundations for permanent and temporary structures:
  - topsoil stripping, temporary drainage installation where required;
  - excavation and disposal of excavated soil for pad and chimney foundations;
  - installation of pylon foundations (pad and column, mini pile, tube pile or bespoke).
- Erection of overhead line structures including temporary structures:
  - layout of steelwork in preparation for erection;
  - assembly (painting if required) and erection of steelwork;
  - installation of insulators strings including fittings;

- installation of protection prior to stringing of conductors, including scaffolding.

- Overhead line structure (tower) dismantling:
  - detachment of conductors;
  - removal of fittings and/or hardware and insulators;
  - tower dismantling in sections and lower to the ground;
  - removal of foundations.
- Stringing of conductors:
  - establishment of machine sites for conductor stringing; including equipotential zones;
  - conductor stringing;
  - conductor sagging and clamping including damper installation;
  - Installation of spacers.
- Re-instatement:
  - removal of construction equipment and reinstatement of ground and restoration of soils;
  - removal of access tracks and bellmouths;
  - removal of construction compounds and reinstatement of ground; and
  - replanting of trees, if applicable.

Foundations

~~4.6.97~~4.6.94 There are various types of pylon foundations used for overhead lines, and these would depend on the ground conditions where the pylon is located. Analysing the results of the geological surveys, the design civil engineer would select the most suitable foundation for each pylon location. Normally pad and chimney foundations are selected for soils with good ground (hard soils) and piled foundations are selected for soft ground or where a high-water table is present. The foundations of the proposed pylons would either be pad and chimney, mini pile or tube pile (or bespoke if required). The selection of foundation type would depend upon the ground conditions shown by geological surveys. The installation of pad foundations would take approximately three weeks for each pylon (four pads). Mini pile or tube pile foundations would typically take approximately four weeks for each pylon. For pylon locations where ground conditions do not easily permit the installation of pad and chimney, mini-pile or tube pile foundations, a bespoke foundation would be required. The design for each bespoke foundation would be subject to the ground conditions encountered.

~~4.6.98~~4.6.95 The construction times mentioned above are estimated and depend on type of soil, number of gangs and equipment available. It is anticipated that any pylons required for the Suffolk Onshore Scheme would have pad and chimney foundations whilst those required for the Kent Onshore Scheme would require tube pile foundations.

Erection of overhead line structure

~~4.6.99~~4.6.96 The steel work would be brought to each pylon working area and laid out in pre-constructed sections or in numbered parts prior to assembly and erection of the pylon. Laying out of the steelwork would typically take approximately three days per pylon. The numbered steelwork parts would be bolted together on the ground. The pylon would be assembled in sections beginning with each bottom leg section being fastened to the foundation steelwork. The pylon would be erected using a mobile crane which would lift the assembled steelwork into position. Linesmen would bolt together the pylon, climbing to each part to help guide the next section into place and fasten the bolts. The number of pylon sections required would vary according to the size of the pylon being built and the lifting capacity of the crane. To lift the topmost sections of the taller pylons a crane with a capacity of up to 250 t may be required for the reach and weight of the sections to be positioned into place. A smaller capacity crane could be used to lift pylon sections up to the limit of reach of the crane considering load to be lifted. Though in this instance the larger capacity crane would still be required to complete the pylon.

~~4.6.100~~4.6.97 Temporary scaffolding and nets would be installed during construction, where required, as a safety measure to protect assets such as roads, railways, PRoW and distribution network overhead lines (where not already moved underground) and could include hedgerows which would be crossed by the proposed overhead line. This is required to protect these features during conductor stringing from the accidental dropping of conductors and any of the associated equipment. The scaffolding would be transported to site using a lorry or tractor and trailer and assembled by hand at either side of the feature being protected. Typically, approximately 8 m^2 of scaffolding would be installed per day. The insulators strings with fittings would be fastened to the cross arms of the pylons, with running wheels hung from the end of the insulators to carry the pilot wires in preparation for installing the conductors. The installation of the insulators would typically take approximately two days per pylon.

Overhead line structure (tower) dismantling

~~4.6.101~~4.6.98 If a pylon is no longer required, it is dismantled and removed from site for recycling and the land reinstated. When the pylons are dismantled during the construction works would depend on the sequence of works and space constraints.

~~4.6.102~~4.6.99 Material from the overhead line, such as steel members from the pylons would be taken for recycling where possible. Specific decommissioning works would include:

- fittings and / or hardware such as spacers dampers, and insulators would be removed from the circuit. The conductors would be winched onto drums in a reverse stringing process;
- the tower would be dismantled, with sections disconnected for removal from site; and
- typically, the foundations would be removed to approximately 1m deep and subsoil and topsoil reinstated.

~~4.6.103~~4.6.100 The methodology for pylon dismantling is dependent on the pylon design, age, condition and site location, although generally, the arms are removed first, the top is lifted off and then the rest of the pylon in box sections.

~~4.6.104~~4.6.101 It is usual for a crane to be used for this purpose. However, if the ground is unsuitable for crane use, a derrick is used for dismantling or erecting of pylon steelwork and sections.

~~4.6.105~~4.6.102 A derrick is a method of supporting steelwork removal by building an internal framework which can be lifted or built to the required height in order to use ropes and pulleys to support the lifting and lowering operations.

~~4.6.106~~4.6.103 A pylon is often cut up into smaller sections by a specialist subcontractor then loaded into a waste vehicle to be transported to the recycling facility. The cutting methodology varies; however, generally it involves a grab attachment which hydraulically cuts the steelwork.

Stringing of conductors

~~4.6.107~~4.6.104 This is the phase of works where the conductors are installed. This is usually done in sections between appropriate angle/tension pylons. The machine sites for conductor stringing (pulling positions) would be sited on interlocking panels laid directly onto the ground surface reducing disturbance to the underlying soils. The machine sites would be sited to avoid individual trees wherever possible. It would typically take approximately one day to establish the area to receive materials and equipment at each conductor stringing site.

~~4.6.108~~4.6.105 The wires (conductors) of the overhead lines would be delivered to the machine sites for conductor stringing using lorries, or tractor and trailer. The conductors are wound onto large cable drums and, depending on the conductor type, each completed drum could weigh up to 8 t, although larger and heavier drums are possible depending on the supplier and the length of conductor. A conductor pulling position would be established at each end of the section with a winching machine (‘winch’) and empty steel reels to accept pilot wires. At the other end of the section the full conductor drums would be arranged near the tensioning machine (‘tensioner’). Light pilot wires would be laid at ground level (and over temporary scaffolding protecting assets such as roads and railway lines) along the length of the section between the pulling positions (note that it is not typically necessary to clear hedgerows specifically for this activity, though some vegetation management could be required). The pilot wires would be lifted and fed through running wheels on the cross arms of all the pylons in the section, and then fed around the winch at the pulling position. The light pilot wires are used to pull through heavier, stronger pilot wires which are in turn used to pull conductors through from their drums. The tensioning machine would keep the wires off the ground and prevent the conductors running freely when the winch pulls the pilot wire. When the conductor is fully ‘run out’, it would be sagged to determine the exact design tension, fastened at its finished tension and height above ground by a linesman working from platforms on the pylons which are suspended beneath the conductors. Additional fittings such as spacers, if required, and vibration dampers, would be fitted to the conductors. To counterbalance the out of balance loading at the tension pylons at the end of a conductor stringing section, it is normal to install temporary backstays or concrete blocks for safety of installation. The temporary backstays or concrete blocks are removed after conductor stringing is completed. Stringing the conductors would typically take approximately four weeks per conductor stringing section.

~~4.6.110~~4.6.106 To provide protection to personnel from the effects of potential differences that may arise whilst lowering, raising or restringing overhead line conductors, the machine sites are required to sit on Equipotential Zones (EPZ's). The EPZ consists of a mat of linked conducting metal panels, on which all the stringing equipment and machinery would sit. They are then electrically bonded together to a common point, with an earthing bus welded onto one of the panels. An EPZ is required for puller / tensioner sites only. The EPZ is designed to ensure that during fault conditions dangerous potential electrical differences do not occur across the body of personnel conductors. The zone must be of sufficient size to enable operatives to operate the winch machine and mount and change the required conductor drums without having to step off the zone.

~~4.6.111~~4.6.107 When installing or working with new conductors, lightning strikes and induced current from adjacent electrical circuits can pose significant dangers to operatives working on the new line. Measures to control the risks are detailed in National Grid's National Safety Instructions (NSIs), and are to be applied when working on, or near to overhead lines and Substations.

~~4.6.112~~4.6.108 When a new pylon is required to be constructed on a point that is on or close to an existing overhead line, outages would be required to construct it, and if required, the removal of an existing pylon that it is replacing. Unless a double circuit outage is available for a long period of time, one of the circuits may need to be diverted away from the existing pylons, so that this diverted circuit can be kept energized whilst the other circuit can be de-energized. This would then allow adequate space for the new pylon to be constructed safely.

Re-instatement

~~4.6.113~~4.6.109 Once the overhead line is constructed, the access tracks and working areas at the pylon site would be removed and the ground reinstated by removing stone and trackways. Soils would be restored to their previous condition. Other surfaces would be reinstated and widened accesses would be restored to the condition they were in at the commencement of the works.

~~4.6.114~~4.6.110 Reinstatement activities mitigate for the intrusive works that have occurred during the project. Additional environmental enhancement works may also be carried out with agreement with landowners where necessary. Reinstatement is agreed with grantors and key stakeholders, including requirements within assents, consents or licenses obtained.

~~4.6.115~~4.6.111 The location of the proposed OHLs and pylons are illustrated in **Application Document 2.14.1 General Arrangement Plans – Suffolk** and **Application Document 2.14.2 General Arrangement Plans - Kent**.

Proposed Underground HVAC and HVDC Cables

~~4.6.116~~4.6.112 Whilst the number of cables and working width vary depending on whether the underground cable is HVAC or HVDC the sequence and method of construction and installation is the same and has therefore been described together below.

4.6.118 4.6.113 Installation of the proposed HVAC and HVDC cables would typically be undertaken within an 63 m and 40 m wide working width respectively, whilst a combined HVDC and HVAC corridor would typically be undertaken within an 78 m wide working width as shown on **DCO/S/DE/SS/1202**, **DCO/S/DE/SS/1209** and **DCO/S/DE/SS/1204** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**). The exception to this is where environmental or engineering constraints mean additional land is required such as where the proposed cable routes cross obstacles such as roads or watercourses using a non-open cut technique. In these locations working widths may be required to be larger. In some areas the construction corridor may be narrowed to minimise the impact on environmentally sensitive sites, for example through a woodland or significant hedgerow. Narrowing the corridor is accomplished by relocating the topsoil and sub soil stockpiles and requires larger construction corridors on either side of the sensitive site to accommodate the additional storage of soil.

4.6.119 4.6.114 There are several cable installation methods which are summarised below.

Open cut installation

Method 1 – Open cut direct buried

4.6.120 4.6.115 Typically utilised in open countryside/agricultural land. Involves the excavation of a trench into which the cables are directly laid. Requires long sections of trenching (typically 800 m – 1000 m) to be excavated and left open to enable the cables to be installed. Dewatering and protection from surface water runoff are specific constraints on this method. Crossings such as at roads or watercourses are often dealt with via the inclusion of a duct block enabling the cables to be installed through the ducts and avoiding the need for these crossing to be left open for significant periods.

Method 2 – Open cut ducted

4.6.121 4.6.116 Typically utilised in open countryside/agricultural land. Involves the excavation of a trench into which the ducts are installed, and the trench backfilled. The pulling tensions on the cable during installation are a constraint with this method as access along the section length is limited, the condition of the ducts to ensure protection of the cable during pulling is vitally important. The benefits of this option are that excavations are only open for a short duration and over a more limited length, this reduces health and safety risks on site and reduces concerns over dewatering and surface water runoff management.

General trenching

4.6.122 4.6.117 Soft, collapsible soils such as sand based soils would require either temporary trench boarding (direct buried) or trench boxing (ducted) to facilitate the containment construction. In firmer soils, 'battered' excavations become more acceptable for both configurations. Lengths of 'open' trench would be around 1 km for normal direct buried configuration whereas a ducted system can be backfilled on a rolling basis and therefore there is significantly less open trench at any one time (approximately 200-300 m). Construction of an open trench in good soils can progress at +100 m per day, dropping to 10 m per day or less in challenging areas such as rock or complex urban environments. We have used an average value of 52 m per day for the assessment of this project.

Cable installation

~~4.6.123~~4.6.118 With an open trench, direct buried configuration, a significant amount of time is required to set up the system to install – these include flat rollers for straight runs, box rollers for corners and careful calculation of pull forces on the cable. A section can usually be installed (two cables) in around four days including moving of rollers and resetting. This is achievable provided the infrastructure is in place (drum laydown and pulling points).

~~4.6.124~~4.6.119 For a ducted system, which may not always be viable due to system constraints, provided that any moves away from the horizontal and vertical planes (bends) are within acceptable parameters, installation can be achieved much quicker – typically two days for a section (two cables) is achievable provided the infrastructure is in place (drum laydown and pulling points).

~~4.6.125~~4.6.120 Cable installation does not need to be undertaken sequentially along the whole route; as a result, installation could occur in multiple sections of the length of the proposed cable route in parallel. This would limit the extent and duration of construction activity at any given location including the length of time that land remains disturbed for. The exact programme would depend on several factors including the underlying ground conditions and installation methods used.

~~4.6.126~~4.6.121 For the Proposed Project, open cut ducted installation is proposed for all terrestrial sections of the route, except the crossing of the A256 in Kent, where a trenchless technology is required. Both marine landfalls are proposed as trenchless installations as well.

Phasing of construction

~~4.6.127~~4.6.122 Open cut cable installation would typically be undertaken in the following sequence:

- utility diversions undertaken by third-party asset owners;
- survey and ground investigations;
- installation of stock proof fencing via mobilisation accesses to segregate works areas;
- vegetation clearance via mobilisation accesses;
- installation of bellmouths and creation of visibility splays;
- installation of remaining stock proof fencing and gates or equivalent if required;
- topsoil stripping, temporary drainage installation where required;
- installation of access tracks (including culverts and bridges), noting culverts and bridges would require use of mobilisation accesses to reach both sides of the watercourse;
- trench dug utilising excavators (or by hand in areas of known buried utilities). Excavated sub-soil would be stockpiled separately from the top soil;
- installation of a base layer of CBS into the cable trench;
- joint bays excavated and a concrete base installed;
- cables or ducts laid in trench;

- cables or ducts are bedded in / surrounded with CBS;
- protective tiles are placed across the width of the trench;
- trench is back filled with excavated sub-soil or thermally suitable material where required (to avoid the alteration of local environmental temperatures around the cables);
- warning tapes would be placed 100 mm above the protective tiles vertically in line with the cable poles;
- topsoil would be reinstated to original soil profile and land re-seeded where required.
- where a ducted solution has been used cables would be pulled through the installed duct system, similarly to the direct buried option cables would be pulled from a cable drum using winches installed at the other end of the ducted section;
- joint bay structure is erected over the joint bay and cables are jointed, joint bay backfilled with CBS, protective tiles, suitable backfill and warning tape as per the cable sections;
- link pillars are installed where required and fencing and gates installed where required; and
- following cable commissioning, haul road is removed, and topsoil reinstated, and land handed back to the landowner. A phased return of land can be considered earlier where suitable, depending on the location and access requirements.

Trenchless crossings

~~4.6.128~~4.6.123 These would typically be utilised where significant obstacles such as major watercourses, roads, railway lines, flood defences or other utilities need to be crossed, and open cutting is not considered a suitable option.

~~4.6.129~~4.6.124 For the Proposed Project, a trenchless installation is required to cross the A256 in Kent. Additional trenchless crossings could be used where the contractor deems them to be an efficient or effective crossing strategy.

~~4.6.130~~4.6.125 There are multiple techniques available with the choice of technique being dependent on the ground conditions and the parameters of the cable installation required. All techniques typically involve drilling under the obstacle and installing a duct or tunnel opening through which the cables can be pulled. The benefits of this system are that the obstacle is largely unaffected by the installation, the design is undertaken to avoid undue settlement and the surface level is monitored throughout the works to ensure agreed tolerances are adhered to. In the case of a rail or road obstruction there would normally be required to be a partial closure during the works for safety reasons.

~~4.6.131~~4.6.126 Trenchless crossings require a significant mobilisation of infrastructure at either end of the crossing, requiring a construction compound to be built at either end. The drilling methods are often slower than trenching which can impact on programme and they can be more expensive than open cut solutions. Some techniques require drilling fluid to be used at high pressures that can lead to frack out, where drilling fluid escapes to the surface during the drilling process. Mitigating the risk of settlement and frack out often requires trenchless crossings to be installed at greater depths than open cut installations which can impact on the thermal properties of the installation and reduce the capacity of the system. This can lead to trenchless solutions being unfeasible from a capacity perspective. Due to the need for separation between drills the overall construction corridor and permanent installation is likely to be wider than an alternative open cut installation.

4.6.1324.6.127 Trenchless installation methods would require 24-hour working, seven days per week.

4.6.1334.6.128 Where a constraint is required to be crossed using a trenchless method, there are a number of methods that can be employed depending on the ground conditions and detailed design. A typical description of each is provided below.

Pipe jacking (Auger Bore)

4.6.1344.6.129 A hydraulic ram or jack and associated boring equipment would be located in a launch pit. The size and depth of the launch pit is dependent upon the depth of the cable (deeper cable requires a deeper and larger pit). A tunnel is then created by progressively inserting clay pipes behind the drill head (driven by the hydraulic jack), with material returned to the launch site (typically via a screw-shaped shaft). One tunnel is required for each cable. The direction of the tunnel is determined by the set-up equipment in the launch pit and it is continuously surveyed. Drilling continues to the reception pit (also constructed prior to drilling, to a depth relative to the depth of cable). The launch and reception pits may require sheet piling and further works to ensure a dry and stable working environment. Following completion of the works, the launch and reception would be backfilled on completion of the crossing and the area reinstated. Topsoil would be reinstated to original soil profile and land re-seeded or released to the landowner for cultivation as it was found.

Horizontal directional drilling

4.6.1354.6.130 A Horizontal directional drilling (HDD) rig and associated equipment would be set up at the launch site. This includes electricity supply (portable generator), drill mud filter, control unit and welfare facilities. Drilling utilises a drill bit, drill head and drilling fluid. Drilling fluid (typically bentonite slurry) assists the drilling process, as well as lubricating and cooling the drill head.

4.6.1364.6.131 A pilot hole is typically drilled first, followed by a series of increasing size bores until the final drill diameter that is required is achieved. Location and direction of drilling can be monitored using the HDD locating system to ensure drilling follows the pre-planned path. Ducting is then pulled back through the drilled hole towards the HDD rig. One cable duct is required for each cable.

4.6.1374.6.132 It is likely that additional ducts would be installed to allow for ease of replacement should any faults be identified in future. Ducts can be capped to ensure no attenuation of water or sediment or to prevent use by animals if left prior to cable pulling. The launch site would be reinstated on completion. Topsoil would be reinstated to original soil profile and land re-seeded or released to the landowner for cultivation as it was found.

Micro boring (micro-tunnelling)

4.6.1384.6.133 This method is similar to pipe jacking, however, it utilises a steerable tunnel boring machine (TBM) to tunnel between a launch pit and a reception pit. Lengths of pipe are inserted behind the TBM as it progresses, and a hydraulic jack is used to drive the pipe forward. Water or mud mix is utilised to fluidise excavated material which is pumped to the launch pit. Cable ducting is pulled through the pipe tunnel following tunnelling through to the reception pit. The launch pit and reception pit require concrete bases to ensure a clean working environment and prevent water entering the working area.

4.6.1394.6.134 The launch and reception pits also require a concrete back wall for the hydraulic jack to work against. The launch and reception pits would be backfilled on completion of the crossing and the area reinstated. Topsoil would be reinstated to the original soil profile and land re-seeded or released to the landowner for cultivation as it was found.

Construction swathe

4.6.1404.6.135 Construction of the cable trenches and associated temporary works are contained within a linear zone known as the construction swathe. The construction swathe for the Proposed Project cable installation varies along the route depending on the specific constraints of the various locations and the required installation, HVDC, HVAC or combined.

4.6.1414.6.136 Network requirements dictate that one HVDC circuit is necessary to meet future demand. Preliminary engineering calculations indicate that the circuit would require two cables, comprising a positive and negative pole. It is anticipated that the cables would be installed in a single trench, approximately 2.3 m wide and 1.5 m deep, however other configurations may be used.

4.6.1424.6.137 The HVAC circuit is proposed as two circuits each with one cable per phase, therefore two trenches separated by a central temporary haul road. The trenches are proposed as approximately 2.45 m wide and 1.5 m deep, with trenches separated by a minimum of 2.4 m (centre phase to centre phase distance).

4.6.1434.6.138 In addition to cable trenches, the construction swathe must accommodate the following:

- Stripping and storage of the topsoil in the construction corridor.
- Installation of drainage filter drains for the capture of water within the swathe.
- Installation of filter drains/swales to intercept the runoff entering the site from the adjacent ground, preventing this creating additional dirty water.
- Excavation of cable trench / trenches of the correct specified width and depth.
- Storage of material removed from the cable trench in preparation for its return if suitable.
- Haul road for the access and transport of plant, equipment and personnel (note that there would be some areas where the haul road diverges from the construction swathe due to site-specific constraints).
- Security fencing.
- Additional space requirements at joint bays and sites of engineering difficulty.
- Tolerance to adjust the positional location of the corridor and its components to practicably accommodate the unexpected.
- Laydown of materials for use.

4.6.1454.6.139 The overall width of the cable swathe for HVDC alignments is therefore approximately 40 m. The width of the swathe would widen to approximately 50 m for locations where trenchless installation methods would be employed. For HVAC alignments, the construction swathe for typical installation is approximately 63 m. At trenchless crossings, the construction swathe may widen to up to 100 m. For combined HVAC and HVDC alignments (e.g. between the proposed Saxmundham Converter Station and Friston Substation), the construction swathe for typical installation is approximately 78 m.

4.6.1464.6.140 Typical construction swathes for HVDC, HVAC and combined alignments are shown in **DCO/S/DE/SS/1202**, Design Drawing **S42_S/TDD/SS/0010** and, **DCO/S/DE/SS/1209** and **DCO/S/DE/SS/1204** of the Design and Layout Drawings (**Application Document 2.13.1 Design Drawings - Suffolk**).

4.6.1474.6.141 The general types of physical constraint identified along the cable route are;

- main rivers, watercourses and ditches;
- major roads crossings;
- railway crossings;
- crossings of existing underground utilities (gas/water pipes, telecommunication, electrical cables, etc.); and
- areas of significance. i.e. designated sites for nature conservation such as SSSI.

4.6.1484.6.142 Where possible the LoD has been reduced to the construction swathe width to limit the overall footprint of the Order Limit, although the cables could be installed anywhere within the LoD. The cable LoD has been locally adjusted adjacent to the proposed Friston Substation. This has been done because design development may require the route of the proposed HVAC connection into the substation to be on the northern side instead of the western side as is currently shown on **Application Document 2.14.1 General Arrangement Plans - Suffolk**. This is to accommodate the ongoing detailed design of Friston Substation being undertaken as part of SPRs projects.

Joint bays and cable jointing

4.6.1494.6.143 Joint bays are required along the proposed underground cable route. Sizes may vary throughout the route, though typically, this would be approximately 13 m in length and approximately 3 m in width.

4.6.1504.6.144 The joint bay would first be excavated to the required depth using a mechanical excavator and supports added according to the existing ground conditions. Again, the depth is determined by the required level of protection and surrounding environment. Trench supports would typically consist of pre-fabricated steel boxes, sheet piles or timber whaling boards, propped in the middle using steel or timber struts. Supports would be delivered to site on the construction haul road by HGV and offloaded using a telehandler or similar. Alternatively, excavations may be battered to a suitable angle to prevent collapse. Excavated topsoil and subsoils would be stored in capped bunds adjacent to the bay, within the construction boundary.

4.6.1514.6.145 A separation membrane would be installed in the base of the excavated trench onto which a reinforced concrete slab is cast to provide a stable foundation for the cable and accessories to be fixed.

~~4.6.152~~4.6.146 The ends of each section of cable would be pulled into the joint bay and supported (using sand bags or similar) ready for the jointing works to be undertaken. If the adjoining cable ducting has not been completed, or jointing works are not programmed to be completed for some time, the joint bay may be backfilled at this point and re-excavated when required.

~~4.6.153~~4.6.147 Cable joints are complex, expensive and easily susceptible to damage. The process of cable jointing is precision work and is extremely sensitive to ambient conditions. The process involves welding of the conductor and re-building of the insulation. It is therefore essential the construction of the joint bay and associated components is carried out in a controlled and precise manner to ensure reliability, as this is fundamental to the operation of the cable system. As such, a temporary shelter arrangement is required, providing a sterile, waterproof and controlled condition for the cable jointing operatives. This is either a pre-fabricated container craned into position over the cable joints or a scaffold type arrangement constructed in-situ and covered by waterproof material. To ensure continuity, the jointing of each cable would be a continuous process, often requiring night and/or weekend working. These activities would take a number of days to complete per joint and require ultra-clean, well-lit and humidity controlled environment.

~~4.6.154~~4.6.148 Upon completion of the jointing works, the cables and accessories would be surrounded with a compacted CBS material to a thickness specified by the cable system design. Cable protection systems, including concrete or plastic tiles and hazard tapes would be added as a warning to any future unsought excavation by third parties. The remainder of the excavation would be backfilled with a thermally suitable material and the ground surface reinstated to the original condition. Link boxes can then be installed where required.

~~4.6.155~~4.6.149 A typical joint bay for a HVAC cable is illustrated on **DCO/S/DE/SS/1203** of the Design and Layout Drawings **(Application Document 2.13.1 Design Drawings - Suffolk)** and a typical joint bay for a HVDC cable is illustrated on **DCO/T/DE/SS/1301** of the **Design and Layout Drawings (Application Document 2.13.3 Design Drawings – Terrestrial General)**.

Cable pulling

~~4.6.156~~4.6.150 Cables are generally manufactured in lengths of between 600-1200 m. These are coiled onto large drums at the factory (often overseas) for transport, arriving at site via a special type of vehicle. The length of cable on a drum is limited by the weight and diameter of the cable reel, as it is required to be transported via public highways. The weight of the drum is typically in excess of 50 t, with an overall vehicle train weight of up to 130 t. As such, careful management of deliveries is required, often including escorts and night movements, to minimise disruption. Cable drums are either delivered directly to the worksite or to a pre-determined location where they are stored for a temporary period and later transferred to a specialist pulling vehicle when required.

~~4.6.158~~4.6.151 Cables are generally pulled in sections, between joint bays. The cable drum is placed at the upstream joint bay location (preferentially at a higher elevation to reduce pulling tension) and the winch unit at the downstream joint bay. Should a ducted system be installed, the winch cable (bond wire) would be attached to a draw wire which has been pre-installed within the ducts during installation. The bond wire would then be pulled through the ducts towards the cable drum location. The bond wire is then connected to a pulling eye, pre welded to the conductor on the end of the cable. This enables the main power cable to be pulled back through the duct system or open trench using the winch and bond wire. Ramps and rollers are installed between the drum and cable trench (joint bay) and bellmouths installed on the ends of the ducts to prevent damage to the cables as they enter. Once the cables are in the final position, the jointing works can be commenced.

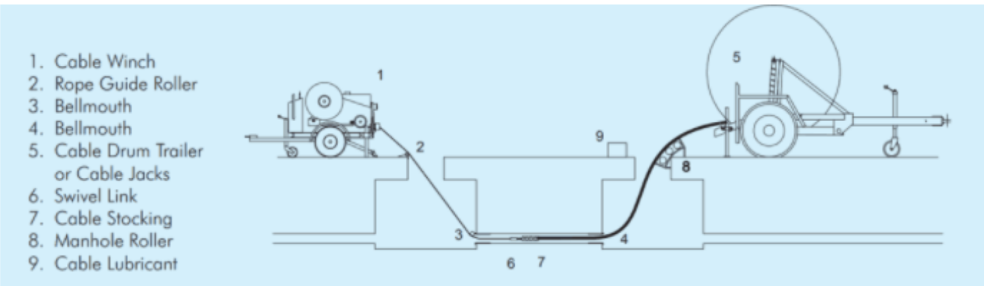


Plate 4.3 Cable laying and pulling equipment - ducts

Noise and Vibration

~~4.6.159~~4.6.152 **Application Document 6.3.1.4.B Appendix 1.4.B Construction Plant Schedule** presents the reasonable 'worst-case' noise and vibration levels from construction plant.

Landfalls

~~4.6.160~~4.6.153 The cable landfalls form the transition between the underground HVDC cable and the marine HVDC cable. The underground HVDC cable and marine HVDC cables are jointed together at the TJB located as close to the coast as possible whilst taking account of any environmental or technical constraints at a particular landfall.

~~4.6.161~~4.6.154 A technical feasibility study has been undertaken at both landfall locations to further understand the feasibility of using trenchless techniques such as HDD or direct pipe to install the cable. For the purpose of this assessment, HDD is considered to have a similar footprint and installation parameters as direct pipe and is therefore presented here in further detail as the reasonable worst case installation method.

~~4.6.162~~4.6.155 In Suffolk, two onshore boreholes were undertaken in September-October 2023 and identified that the depth of the superficial deposits in the RSPB North Warren Reserve and beach area are less than 9m and generally less than 5 m, allowing the HDD profile to have sufficient depth in competent Crag to avoid the risk of surface frac out of drilling fluid. The 1,525 m length for the HDD is well within the capabilities of a maxi HDD rig and there is the potential that the entire length could be forward reamed to minimise the amount of offshore working (see Suffolk Landfall Feasbility Technical Assessment Report within Appendix A of **Application Document 7.3 Design Development Report**).

~~4.6.163~~4.6.156 In Kent, five onshore boreholes have been completed along the landfall route and identified that the majority of the Thanet Beds are expected to form a stable borehole and that majority of the indicative HDD profile would be in the Newhaven Chalk. An indicative HDD profile has the drill at 15-20 m depth of cover beneath the land section of the drill, the shallow lagoon, and the saltmarsh. The majority of the drill is intended to remain within the Newhaven chalk at a length of 940 m, which is well within the capabilities of a maxi HDD rig. There is also potential that the entire length could be forward reamed to reduce the amount of intertidal working (see Kent Landfall Feasibility Technical Assessment Report within Appendix A of **Application Document 7.3 Design Development Report**).

~~4.6.164~~4.6.157 The Suffolk landfall would be installed by trenchless solution such as HDD from the TJB illustrated in **DCO/S/DE/SS/1211** of **Application Document 2.13.1 Design Drawings - Suffolk** to approximately 7 m LAT. The Kent landfall would be installed by a HDD from the TJB illustrated on **DCO/K/DE/SS/1257** of **Application Document 2.13.2 Design Drawings - Kent** to extend as far as practicable, in order to minimise the impact on the intertidal saltmarsh that extends from the shoreline up to 250 m from the shore. As shown in Table 4.10 Indicative Construction Programme, the enabling works and installation works for both the Suffolk Landfall and Kent Landfall would last for a duration of approximately 6 months.

Horizontal directional drilling

~~4.6.165~~4.6.158 The HDD technique would drill beneath the ground surface (onshore to offshore) to avoid the need to trench the cables on the surface and is the installation option at both landfalls. A detailed HDD sequence is described below and indicative alignments for both landfalls presented in **Application Document 2.13.4 Design Drawings – Offshore.**

~~4.6.166~~4.6.159 Preliminary landfall works would require establishment of access tracks and the site work areas. Preparation typically requires topsoil stripping of the routes and sites with topsoil stored in bunds along the routes and site boundary. The tracks and HDD compound are normally constructed with stone overlain on geogrid and geotextile. Access track and site mobilisation is scheduled as 24 days, typically of 12 hour / 5.5 day working. Due to the ground slope, the compound may require levelling prior to installation of the drilling system.

~~4.6.167~~4.6.160 Delivery of onshore HDD equipment typically requires 20 No. HGV loads over two days. A 150 t - 200 t crane may also be required for positioning equipment on those two days.

~~4.6.168~~4.6.161 The onshore HDD rig and spread would be used on an around the clock basis for 120 days in total for completion of the drilling and duct installation.

~~4.6.169~~4.6.162 The HDD methodology is expected to be as follows:

- **Installation of rig anchor:** Either poured concrete block or sheet piled.
- **Installation of Temporary Casing:** 20 m to 40 m length, installed by drilling or hammering.
- **Pilot Drilling:** Typically 15 m – 20 m below surface. Possibly jetted, but potentially via downhole motor drilling. Cuttings would be disposed of appropriately off site. At Suffolk, when the pilot exits to the sea floor, drilling fluid would be lost to the sea. At Kent, when the pilot exits in the intertidal area, drilling fluid would be captured if practicable.

- **Reaming:** To enlarge the bore, a reamer is pushed or pulled through the pilot bore. Two options exist, forward reaming where drilling fluid flows back to the entry and pull reaming where fluid flows to the exit. The use of forward reaming requires suitable geology and would be determined following ground investigations. The use of pull reaming requires either capture of fluid at the exit for recycling, or discharge of fluid to the sea. A combination of the push and pull methods may be used to minimise fluid losses to the sea.
- **Duct Installation:** Two standard duct installation methods are used for landfalls; pushed and pulled. Pushed duct installation requires suitable ground conditions. The duct is assembled behind the drilling rig along the onshore cable route before being pushed in through the borehole until it emerges within the exit pit. A pulled installation uses a duct floated to the exit point that is attached to the drilling rods and pulled into the towards the drilling compound above MHWS. The duct is fabricated to length and stored at a suitable location, either moored or onshore with easy access to the sea, before being towed to site by vessels.
- **Duct End Works**: Following duct installation, a messenger wire would be installed in the duct with sealing flanges attached to the duct ends. The duct ends would then be stabilized and secured until the cable installation. Up to five temporary rock bags/concreate mattresses would be used to stabilise the ducts and would remain in position until approximately one week before cable pull-in.

~~4.6.170~~4.6.163 At both landfalls, HDD installation would be a 24-hour operation where viable to minimise overall installation time, maximise the use of suitable weather windows and take advantage of vessel and equipment availability. The noise profile suggests that for HDD from the onshore, maximum onshore noise levels would not be expected to exceed 70 dB(A) within approximately 7 m of works. A significant noise source on the drilling site is the fluid recycling system which can generate up to 83.2 dB(A) at 2 m distance.

~~4.6.171~~4.6.164 HDD exit pits at the Suffolk landfall would be positioned wholly within the subtidal area, avoiding impacts to the intertidal at this location. The use of a jack up barge would be required to support the creation of the exit pits in advance of breakout.

~~4.6.172~~4.6.165 Due the extent of the intertidal zone at Kent, HDD exit points would be located approximately 105 m to 140 m seaward from the edge of the saltmarsh. Pits would be excavated, and potentially a small cofferdam would be installed either before or immediately after punch out of the pilot HDD to contain drilling fluids (four punch outs in total) as a reasonable worst case scenario. The equipment would include up to four small excavators (15-20 t), two tractors, hovercraft and ancillary equipment such as drilling pipes, pumps and generators. Excavators would remain within a maximum area of 120 m x 180 m around the exit pits. As the exits are in the upper intertidal area, access would be via the corridor from the former hoverport rather than transportation by sea at the top of the tide. Depending on ground conditions, either excavators would tow sledges of equipment or tractors would tow trailers with equipment to the exit. The noisiest equipment during these activities is expected to be the excavators (**Application Document 6.3.1.4.B Appendix 1.4B Construction Plant Schedule**). Pumps and generators would be in super-silenced units, if full high pressure mud pumps are required, they typically generate noise of 77dB at 2.5 m distance and generators 71 dB at 1.0 m distance. A 20 t excavator typically generates 99 dB(A).

4.6.1744.6.167 Cofferdams at HDD exits may be installed at Kent which could potentially be constructed by either prefabricated filled tanks (as used on Walney extension), a barge with moon pool, grounded after positioning at high tide (as used on the Dolwin projects in Germany) or piled. Ground conditions indicate 6 m of sediments overlying chalk at exit, so vibropiles would be used if pilling is deemed necessary. This assessment has assumed 9 m piles founded to 6 m depth below ground level. Based on previous works, it is anticipated that 4 days is required to install a coffer around a single HDD exit, so up to 16 days of piling for installing on all four exits.

4.6.1754.6.168 Breaks of seven to 14 days would be in place between the installation of the four ducts.

4.6.1764.6.169 At both landfalls, demobilisation is scheduled for ten days. The access tracks and HDD working area are normally left in place for TJB construction and cable pulling works, and reinstated once cable installation is completed.

4.6.1774.6.170 A summary of landfall installation parameters is presented in Table 4.11.

Drilling fluid

4.6.1784.6.171 Drilling fluids would be used to suspend rock cuttings and carry them out of the borehole, cooling the drilling equipment, clearing debris from the drilling bit, sealing the borehole and reducing friction on the drilling equipment.

4.6.1794.6.172 The drilling fluid is comprised of bentonite and water. Bentonite is a non-toxic and inert natural clay that forms a gelatinous and viscous fluid. The drilling fluid is 4% bentonite and 96% water. Bentonite is listed by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) as non-CHARMable (Chemical Hazard Assessment and Risk Management), and it is on the Pose Little or No Risk to the Environment (PLONOR) list. To condition the water to the correct pH, soda ash is added at <0.1% of the fluid volume. Small amounts of environmentally approved additives may also be used to fine tune the fluid properties.

4.6.1804.6.173 Some drilling fluid and solids (including drill cuttings and drilling mud) would be lost to the marine environment during breakout, reaming and during duct installation. Unplanned losses of drilling fluid occur when HDD's encounter fractures, fissures, voids, or ground with insufficient strength to resist the pressure imparted by the drilling fluid. Losses to the surface are termed "frac out" or "breakout".

4.6.1814.6.174 Mitigation against surface frac out or break out is by:

- ensuring sufficient ground investigations understand the ground strength to inform a suitable design;
- design a profile sufficiently deep for the methodology and conditions, with hydrofracture modelling used to check that there is sufficient factor of safety;
- use of a drilling fluids engineer to design and monitor the fluid properties;
- ensure that the HDD bore is sufficiently clean of cuttings during drilling;
- monitoring fluid pressures in the bore, and returns to the entry pit during drilling; and
- the use of "spotters", personnel stationed above the drill line to look for any frac out or break out.

4.6.1824.6.175 If drilling fluid losses occur, lost circulation material (LCM) may be added to seal the ground. As a last resort, cementitious grout may be used to seal fractures.

Contingency measures for unplanned drilling fluid losses

~~4.6.183~~4.6.176 If surface frac out or break outs occur the drilling would immediately stop to prevent any further fluid being pumped. A sump would be dug, or sandbags positioned, to contain the fluid. It would then be pumped back to the HDD site or transported by tractor and bowser. Any bentonite frac out in freshwater environments would be removed from the floor of the pond, stream or drain by suction hoses. Following clean-up of the frac out, the drill would be restarted to test if the bentonite drilling fluid has sealed the zone. If the zone has not sealed LCM can be pumped, allowed to set, then tested. This process may need to be repeated a number of times. In extreme cases cementitious grout may need to be pumped into the zone and allowed to set to effect a seal.

~~4.6.184~~4.6.177 At the Suffolk landfall, the exit points are located in c. 7m LAT, therefore if there is release of drilling mud at the exits, the bentonite flocculates and breaks down when it comes into contact with seawater with the bentonite clay particles dropping out of suspension over time.

~~4.6.185~~4.6.178 At the Kent Landfall, access for suitable vehicles might be possible from the ramps to the north in the former Hoverport site, but it would be tidally restricted and restricted to the unvegetated section of the intertidal area. Access to the vegetated area is likely to be on foot with the equipment being carried by hand.

~~4.6.186~~4.6.179 If bentonite drilling fluid cannot be effectively captured in the intertidal area it would disperse naturally. Bentonite flocculates and breaks down when it comes into contact with seawater with the bentonite clay particles dropping out of suspension over time. For fresh/brackish water, bentonite drilling fluid would need to be pumped out in order to be removed.

~~4.6.187~~4.6.180 Following clean-up of the frac out, the drill would be restarted to test if the bentonite drilling fluid has sealed the zone. If the zone has not sealed LCM can be pumped, allowed to set, then tested. This process may need to be repeated a number of times. In extreme cases cementitious grout may need to be pumped into the zone and allowed to set to effect a seal.

Cable pull-in

~~4.6.188~~4.6.181 At both landfalls, a jack up barge or similar would be required to bring the HVDC cable (and FO cable if being installed in the same duct) to the location of the exit pit. In addition to this, up to four excavators may be required to assist with the cable pull-in at the Kent landfall due to the extent of the intertidal at this location. Activities would be conducted across all tidal states over two consecutive 12-hour shifts.

~~4.6.189~~4.6.182 The temporary protection at the breakout point and duct would be removed. Within the exit pit, the end of the installed duct may need to be exposed using a mass flow excavator. A bellmouth (a device which is used to help guide the cable through the cable duct and avoid damage to both the cable and the duct) would be installed within the exit pit to guide the cable into the duct. The cable lay vessel would bring the HVDC cable (and fibre optic cable if being installed in the same duct) to the location of the exit pit. The HVDC cable (and fibre optic cable if being installed in the same duct) would be connected to the messenger wire and winched landward through the duct. The cable would be winched to a position past the TJB where it would be anchored and jointed to the onshore cables. The bellmouth would then be removed and the duct sealed.

~~4.6.190~~4.6.183 The cable may be fixed in the duct using an appropriate material, such as grout, bentonite or similar which would be pumped into the duct from the landward end, with a small amount of material lost from the bleed valve at the seaward end, although this loss would be minimised as far as practicable.

~~4.6.191~~4.6.184 Access to the intertidal area in Kent is required on four separate occasions (one time for each duct) up to 30 days apart.

~~4.6.192~~4.6.185 Post-installation protection such as rock bags/concrete mattresses would then be added to stabilize the HDD exits, replacing the existing temporary protection. This protection would be buried. The top of the duct would be approximately 1.1 m below the seafloor and the top of the rock bags/mattresses laid on top approximately 0.5 m below the seafloor. In depths shallower than 10 m, cables would be buried using the most appropriate method(s) depending on the seabed conditions. Burial techniques are outlined in further detail in the next section Submarine cable installation.

Summary

~~4.6.193~~4.6.186 Table 4.11 presents an indicative summary of landfall installation parameters at the Suffolk and Kent landfalls.

Table 4.11 Summary of landfall installation parameters

Aspect	Suffolk landfall	Kent landfall
Nearshore vessels / equipment	Area of Seabed disturbance from Jack up Barge, as a result of spud cans: At each Jack-Up location: 50 m^2. 4 locations = 200 m^2.	One barge / Jack-Up or back-hoe dredger. Area of Seabed disturbance from Jack up barge, as a result of spud cans: At each Jack-Up location: 50 m^2. 4 locations = 200 m^2. Area of seabed disturbance from CLB: 32 m^2 (at each anchor worked location). Each anchor 2 m in length and deployed up to 600m from CLB. Area of seabed disturbance from back-hoe dredger, which maintain position via anchor or spud can – 50 m^2 at each exit pit location.
Transition Joint Bay (TJB) dimensions	10 –15 m by 2-3 m width and 2-3 m depth. Note that this would be buried to allow 1.5 m clearance above the TJB for agricultural activity. Each duct would have an individual TJB.	10 –15 m by 2-3 m width and 2-3 m depth. Note that this would be buried to allow 1.5 m clearance above the TJB for agricultural activity. Each duct would have a separate TJB.
Completed boreholes parameters	Number of boreholes - 4 Length of boreholes – approximately 1.525 km Diameter of boreholes – 400 – 660 mm	Number of boreholes – 4 Length of boreholes – approximately 0.943 km Diameter of boreholes – 400 to 660 mm

Aspect	Suffolk landfall	Kent landfall
HDD exit pit excavation	Area of seabed directly impacted by work associated with excavation of exit pits (incl. equipment spread) - 200 m^2 Depth of lowering – 0 m –2.0 m below seabed level.	Area of seabed directly impacted by work associated with excavation of exit pits (incl. equipment spread) - 200 m^2. Depth of lowering – 0 m – 2.0 m below seabed level.
Break out point post installation protection requirement	Burial *in-situ* post lay. The Coralline Crag shoal/outcrop is in close proximity to the west of the break-out point and occurs as subcrop to the soft sediments. No pre-cut trenching would be undertaken in the Coralline Crags due to the sensitivity of the sediment circulation system. Number of rock bags – up to 5 per exit point or 5 mattresses per exit point laid perpendicular along route. Area of pre-cut trenching – 0 m^2 Preference is lowering of cable and HDD bellmouth to minimum of 1.5 m below mean seabed level.	Burial *in-situ* post lay rather than pre-cut trenching due to likelihood of infill on a tidal cycle basis. Number of rock bags – up to 5 per exit point or 5 mattresses per exit point laid perpendicular along route. Area of pre-cut trenching – 0 m^2 The location is accessible at low water, so preference is lowering of cable and HDD bellmouth to minimum of 1.5 m below mean seabed level.
Drilling fluid loss at the surface	Drilling fluid discharged per borehole – 1,810 m^3 Solids discharged per boreholes - 324 m^3	Drilling fluid discharged per borehole – 10 m^3. Solids discharged per boreholes - 0.5 m^3.
Temporary Cofferdam dimensions (indicative dimension per exit point)	Not required.	Length –10-15 m Width –3-5 m Depth – 2 m below seabed level Temporary measures would need to be put in place to prevent premature backfill at the exit points for the trenchless solution during receipt of drill system, installation of duct liners, installation of pull-in bellmouth and during the pull-in and lowering operations. It is critical not to allow sediment to accumulate and cause friction / sediment blockage during able pull-in.
Duration of HDD drilling and duct installation	24 hours / 7 days estimated 120 days for four HDDs	24 hours / 7 days estimated 120 days for four HDDs

Aspect	Suffolk landfall	Kent landfall
Depth of HDD	17 m - 25 m	18 m – 20 m.
Duration of cable pull in	12 hrs / 4 days includes 1 day for preparation – assumption is pull-in would be 1 tidal cycle during daylight hours.	12 hrs / 4 days includes 1 day for preparation – assumption is pull-in would be 1 tidal cycle during daylight hours.

Proposed Marine Cable

4.6.1944.6.187 This section is supported by **Application Document 2.5.3 Work Plans – Offshore**, **Application Document 2.13.4 Design Drawings – Offshore** and **Application Document 2.14.3 General Arrangements Plans – Marine** and should be read alongside the Offshore Scheme description.

4.6.1954.6.188 Installation of marine HVDC cable installation includes the following activities:

- ground preparation as required, and cable laying activities at the landfall sites;
- pre-lay seabed preparation activities along the route below MLWS (including route clearance, removal of Out of Service cables, pre-grapnel run and any pre-sweeping);
- construction of cable crossings;
- installation and burial of the subsea cables; and
- placement of external cable protection (as required).

Installation vessels

4.6.1964.6.189 A range of different vessels are expected to be used during cable installation. These are expected to include:

Cable lay vessel (CLV)

4.6.1974.6.190 The CLV would be a specialist ship designed to carry and handle long lengths of heavy power cables, the CLV would be equipped with Dynamic Position (DP) system. The shallowest depth in which the cable ship can operate would depend on the vessel used, however at this stage it has been assumed that larger vessels such as a CLV would not be expected inshore of the 10 m depth contour. Cables may be installed either by simultaneous lay and trenching or cable lay without trenching (Table 4.12).

Cable barges

4.6.1984.6.191 Cable barges could be used in the shallower waters at landfall. A jack-up barge with up to four spud-can legs, each with an up to 8 m diameter and giving a footprint of approximately 50 m^2 may be used at each work location. One work location is assumed for each of the four completed cable ducts, giving a total footprint of approximately 200 m^2 at each landfall.

~~4.6.199~~4.6.192 Flat-top pontoon barge(s) would be fitted with the necessary cable storage and working equipment and up to an eight-point mooring system which would be used to manoeuvre the barge during installation activities. Each anchor could be up to 2 m in length and would be deployed up to 800 m from the barge to allow the barge to hold station, whilst the installation works are undertaken. A combined seabed footprint of up to 32 m^2 at each anchored work location is anticipated (Table 4.12).

Rock placement vessels

~~4.6.200~~4.6.193 A rock placement vessel features a large hopper to transport rock to the required location and a mechanism for deployment of the rock on site. The standard deployment techniques are:

- Flexible fall pipe – a retractable chute is used to control the flow of rock to the seabed. At the end of the fall pipe, a fall pipe remotely operated vehicle is mounted allowing for accurate control of the end of the fall pipe above the seabed and to survey rock placement locations; or
- Side placement – rock is placed over the side of vessel in a controlled manner. A side-placement vessel is typically used for shallow water rock placements. This would be done using either grabs or a side placement unit to ensure accurate placement and controlled rock flow.

~~4.6.201~~4.6.194 Where cable protection using rock placement is required, a targeted placement method e.g., fall pipe vessel would be used rather than using vessel-side discharge methods.

Guard vessels

~~4.6.202~~4.6.195 Guard vessels may be required to maintain surveillance around the CLV, cable barges or other vessels with restricted maneuverability, particularly in areas of high-density marine activities, where it is considered necessary to ensure other vessels keep clear of the installation activity to avoid the risk of collision.

~~4.6.203~~4.6.196 Additionally, they may be required to protect the cable prior to trenching or external protection and also to protect free ends of cable left on the seabed whilst the CLV is reloading. Similarly guard vessels may be required to protect crossing points with in-service 3rd Part Assets, until external protection is completed.

~~4.6.204~~4.6.197 All guard vessels would use Automated Identification System (AIS) to monitor vessel activity and predict possible interactions, as well as engaging with vessels in the area and/or in conjunction with the SUNK vessel traffic system, in the most trafficked area of the route.

~~4.6.205~~4.6.198 Traditionally, approved guard vessels are drawn from the local fishing fleets where possible, controlled by an experienced management company (Table 4.12).

Specialised support vessels

~~4.6.206~~4.6.199 Specialised support vessels may be required to support a range of other activities, including surveys using remotely operated vehicles (ROV) or geophysical equipment, diving activities, personnel transport, pre-lay route clearance, post-lay cable trenching (e.g., ploughing, jet trenching), installation of required cable protection system.

Requirements for exclusion/safety zones

~~4.6.207~~4.6.200 Notices to Mariners would be issued by the contractor advising of upcoming installation activities, and a minimum 500 m Recommended Restricted Zone around construction vessels (identified by the standard marine shapes and lights).

~~4.6.208~~4.6.201 Guard vessels or support vessels would be in attendance to ensure that any approaching vessels are requested to keep clear.

~~4.6.209~~4.6.202 When crossing pilotage or traffic zones, then the appropriate VTS (vessel traffic service) would also advise approaching vessels.

~~4.6.210~~4.6.203 A longer-term safety zone may be required at any wet stored cable end, but if so, this would have a permanent Guard Vessel.

~~4.6.211~~4.6.204 In addition, AIS monitoring may be used to check for incursions into safety zones and provide surveillance in areas less trafficked by construction vessels.

~~4.6.212~~4.6.205 It is not envisaged that any permanent safety/exclusion zones are required although fishers are encouraged not to trawl directly over the cable, in accordance with the European Subsea Cable Association (ESCA) guidelines.

Table 4.12 Summary of installation vessels

Vessel	Description
CLV (simultaneous cable lay and trenching)	Operational speed - 0.5 km to 5 km per day Transit speeds - 6 knots to 12 knots
CLV (cable lay without simultaneous trenching)	Operational speed – 2 km to 7 km per day Transit speeds - 6 knots to 12 knots
Cable Barges	Operational speed - stationery Transit speeds - 4 knots to 10 knots
Trenching Vessels	Operational speed - 0.5 km to 5 km per day Transit speeds - 6 knots to 12 knots
Guard Vessels	Operational speed – 0 km to 7 km per day Transit speeds - 4 knots to 10 knots
Support Vessels	Operational speed - up to 7 km per day Transit speeds - 6 knots to 12 knots
Rock Placement Vessels	Operational speed - 0.5 km to 3 km per day Transit speeds - 6 knots to 12 knots

Marine pre-installation activities

Pre-lay surveys

4.6.2134.6.206 Seabed surveys would be carried out prior to installation to reconfirm existing geotechnical and geophysical information about seabed conditions, bathymetry, ground conditions, and other seabed features.

Pre-installation surveys may involve a range of standard marine survey techniques including:

- Bathymetry: Multi-Beam and Single Beam Echo Sounders (MBES and SBES) to record water depth, prepare a three dimensional (3D) digital terrain model of the seabed, and to identify relevant bedforms/areas of mobile sediments.
- Side Scan Sonar (SSS): Mapping of the seabed surface and identification of sediment types. Obstacles lying on the seabed, such as wrecks, debris, pUXO, and surface-laid or exposed pipelines and cables that might impede cable installation can be identified from the SSS outputs.
- Sub-Bottom Profiling (SBP): Directing a pulse of acoustic energy into the seabed and using reflections from the sub-surface geology to assess the thickness, stratification, and nature of the seabed sediments.
- Magnetometer/Gradiometer: Passively detect magnetic anomalies compared to the earth's magnetic field. Such anomalies can be caused by geological faults and buried metallic objects such as pUXO, pipelines, cables and archaeological features.
- Benthic Ecology: Drop Down Video or Remotely Operated Vehicle (ROV) mounted cameras may be used to confirm the locations and extents of sensitive benthic habitats or features. This would inform micro-routeing of submarine cable systems to avoid or minimise interactions with these features in so far as practicable.
- Geotechnical: Vibrocore and Cone Penetration Test (CPT) samples may be obtained to inform engineering method decisions, micro-routeing and installation tool selection at specific locations. This would verify whether ground conditions are suitable for cable trenching as well as to assess the bearing capacity of the seabed sediments with regards to crossing structures and trenching equipment intended to be used.
- Visual inspection by ROV might be required of submarine assets to be crossed.

Cable route clearance

4.6.2144.6.207 Route preparation would involve clearance activities to ensure the installation corridor is clear of boulders, dropped object debris and other obstacles. Removal of out-of-service (OOS) cables would be required, along with boulder/debris clearance using either grapnels or ROVs and grabs.

4.6.2154.6.208 At present, no expected boulder removal is anticipated to be required along the route. However, in the event that boulders are identified and considered as an impediment to the construction during the pre-installation survey, these would be removed by either a subsea grab or a displacement plough (although the latter is unlikely to be used by the Proposed Project) or a combination of both depending on site conditions. The grab is deployed from a stationary vessel, and it removes the boulders individually with the assistance of a ROV. The plough is towed by the vessel, and it displaces the boulders along the route as the vessel moves forward.

4.6.2164.6.209 A pre-lay grapnel run (PLGR) is also expected to be completed, involving towing a heavy grapnel with a series of specially designed hooks along the centre line of the route, to confirm the installation route is clear of obstacles. Cable route clearance using the methods described here would seek to avoid areas of known sensitive habitats and/or features and would not be used near in-service third-party assets.

Pre-sweeping

4.6.2174.6.210 Pre-sweeping would be required if areas of large sand waves are identified within the Offshore Scheme which cannot be avoided. Pre-sweeping may be performed using a variety of tools including dredgers, MFE or controlled flow excavators (CFEs).

4.6.2184.6.211 The amplitude of mobile bedforms need to be reduced to ease cable installation and to achieve an ideal burial depth (installation in the non-mobile section) for the lifetime of the system. The common practice involves the removal of the mobile layer sediments by Trailing Suction Hopper Dredging or MFE. The Trailing Suction Hopper system involves lowering a dredging arm to the seabed with high pressure water pumps flushing water into the seabed and the resulting loosened sediments are suctioned up into the hopper of the vessel and later disposed of. In the MFE technique, high volume of water is produced and directed downwards onto the seabed thus loosening and dispersing the mobile sediments.

Unexploded Ordnance (UXO)

4.6.2194.6.212 A high-level desktop study risk assessment of UXO was undertaken in summer 2021 to inform the subsequent geophysical and geotechnical seabed survey undertaken in Autumn 2022. The UXO risk was assessed as High and Medium throughout the Offshore Scheme Order Limits. As part of the seabed survey, single source magnetic data was collected to provide an overview of the distribution of magnetic anomalies and to cross-check with the desk-based risk assessment, where areas of known high UXO densities have been identified though a magnetometer survey in 2023.

4.6.2204.6.213 A detailed UXO survey; including use of multiple gradiometers, ROV inspections combined with high resolution MBES, is planned to be carried out in 2025 to better detect and define potential UXOs and to enable rerouting away from targets throughout the route. Micro-routeing around isolated targets would be undertaken, with a closest point of approach to the target, based on the eventual installation methodology.

4.6.2214.6.214 Whilst avoidance would be the preferred approach, if UXO clearance is necessary, the activity would be undertaken in accordance with approved industry practices for removal and disposal/waste management of ordnance. This may include detonating UXO in place or lifting and relocating to a designated storage or demolition area, for safe disposal.

4.6.2224.6.215 Table 4.13 provides a summary of pre-installation activities.

Table 4.13 Summary of pre-installation activities

Method	Description
Boulder Plough or Grab	If boulders are encountered the normal clearance swathe would be +/- 10 m from planned installation route position list (RPL).
Pre-lay Grapnel Run	Width- Swathe of 1 m–3 m. Length – 120 km.
Sand wave lowering (Pre-sweeping) Assumption is up to 3 m of sand may require to be pre-swept above the non-mobile reference level. Due to the high energy environment and expectation that the mobile bedforms would migrate at each storm event, a realistic assumption of 2 m sand removal is made along the interval designated for Pre-sweeping (KP96.32 to KP113.883).	Removal Width- Swathe of 10 m–20 m. Length – 17.563 km. Area – 351,300 m^2 Average depth of sand to be removed (where there are sand waves) - 2 m Volume of material – approximately 250,000 m^3 Deposit Area – 351,300 m^2 of disposal area; within the route corridor There is no designated disposal area, the sand would be deposited within the Order Limits within the area of pre-sweeping in such a way that the local currents would not backfill the pre-sweep area prior Dto cable installation and protection. The mechanism to infill the rock trench and allow the seabed to revert to natural bedforms is by natural backfill and sediment circulation / deposition. Volume – as above: approximately 250,000 m^3.
Sea trials	Width- Swathe of 10 m–20 m. Length – Minimum 1 km. Note: Sea Trials are not currently envisaged.
UXO Inspection	To be estimated after 2025 UXO survey. Separate licence to be submitted.
UXO Removal (Lift and Shift)	To be estimated after 2025 UXO survey. Separate licence to be submitted.
UXO Removal (Detonation)	To be estimated after 2025 UXO survey. Separate licence to be submitted.

Submarine cable installation

4.6.2234.6.216 Cable installation operations would be performed on a 24 hour basis in order to minimise installation time and therefore the duration of any disruption to sensitive environmental receptors, as well as navigation and other sea users. 24 hour operations would also maximise available weather opportunities, as well as vessel and equipment availability. 24 hour installation also reduces the risk to the cable itself during installation, to prevent undue tension on the cable and cable handling accidents

Cable lay

~~4.6.224~~4.6.217 The following cable laying methodologies may be used:

- Simultaneous cable lay and trenching/burial (SLB); and
- Surface cable lay followed by post lay trenching of cables/burial (PLB).

~~4.6.225~~4.6.218 SLB is becoming more widespread as installation contractors design and build their own ploughs. It has the advantage of providing immediate protection to the cable but requires the CLV to be longer on site due to the slower speed compared to surface laying. This may become an issue in areas where weather patterns are unpredictable. It does however reduce the overall duration of lay and protection works. SLB is not being encouraged for Sealink due to the nature of the seabed conditions found along the route.

~~4.6.226~~4.6.219 PLB separates the lay and protection activities, enabling the CLV to lay quickly and then move onto other operations whilst a separate spread undertakes the burial activities. This also has advantages in that a wider range of burial tools may be considered, depending on the nature of the seabed. Rate of progress for PLB is approximately 10 km -12 km per day. Rates depend on seabed sediments and required depths of lowering. For Sea Link, the majority of route is London Clay so rates would be lower than for sands and less cohesive materials.

Cable jointing

~~4.6.227~~4.6.220 Offshore cables would be installed in sections (with joints between the sections). It is, however, possible, given the length of the cable, that no field joints would be required during construction, but this would depend on the contractor, capacity of the lay vessels, lay vessel availability.

~~4.6.228~~4.6.221 Wet storage of cable may be required if the contractor elects to have a first end pull-in at both landings. This would require a field joint at some point on the cable. The first section of cable would have a length wet-stored for subsequent recovery and jointing.

~~4.6.229~~4.6.222 Field joints may be either ‘in-line’ or ‘omega’ (hairpin) types. In-line is used where a second length of cable is joined to the first and lay continues in the same direction. An omega type joint is where the two sections of cable have been laid in opposite directions and require a joint. A cable repair requires two joints and typically has one of each. A field joint casing is usually designed to go through the PLB systems, but not with SLB systems. However, the configuration of an omega joint with tight bends may allow some access for PLB systems. In areas not accessible to PLB systems, either controlled flow excavation or rock protection such as mattresses and rock bags (or a combination of both) is used to complete the protection.

~~4.6.230~~4.6.223 A single joint takes in the order of 5–7 days to complete. Where the cable is bundled, and depending upon the facilities on the CLV, then simultaneous operations may take place, meaning both cables can be done in a similar time. The time to protect the inline joint by trenching or jetting would be in the order of 8–12 hours. An omega joint would require a larger seabed area than an inline joint as more cable is required – at least 2 x water depth plus the deck length of the vessel.

~~4.6.231~~4.6.224 Sea Link is anticipated to have one omega joint outwith the SUNK, allowing two cable lay campaigns although this would depend on the selection of the CLV as new vessels are coming into the market capable of carrying the full length in one load.

Cable trenching

~~4.6.232~~4.6.225 The standard post lowering and burial methods are listed below, followed by an outline description. The choice of burial tool would be informed by the findings of the pre-installation surveys and micro-routeing requirements and would be assessed to confirm suitability for the expected seabed sediment conditions prior to award of the installation contract. There are four generic types of equipment for trenching the cables:

- Cable burial ploughs (displacement or non-displacement);
- Jet trenching (towed, free swimming or tracked);
- Mechanical trenchers (tracked); and
- Mass (or controlled) flow excavators (MFE).

Cable burial ploughs

~~4.6.233~~4.6.226 Ploughs are large machines towed behind a vessel that create a trench into which the cable is laid. This trench is then normally left to backfill naturally but can sometimes be backfilled manually. Ploughs may be used for simultaneous lay and burial or for pre-lay trenching. Ploughs are best suited for relatively soft sediments.

~~4.6.234~~4.6.227 There are two types of cable ploughs: displacement ploughs (creating an open trench for the cable) and non-displacement ploughs (lowering the cable into the sediment). Non-displacement ploughs are towed either by the CLV or an auxiliary vessel following the CLV.

Jet trenching

~~4.6.235~~4.6.228 Jet trenchers use high pressure water jets to fluidise the seabed and bury the cable, they are most effective in soft sediments, non-cohesive and normally consolidated sediments.

~~4.6.236~~4.6.229 Jet trenchers may be self-propelled ROVs or they may be towed sledges. Both use water jets to fluidise the seabed in front of, and around the cable, so that the cable sinks into the sediment under its own weight.

~~4.6.237~~4.6.230 In medium to coarse sands and in gravels, the reconsolidation of fluidised sediments is significantly faster than in fine sands and silts. Jet trenching is a viable technique in a wide range of sediments, although performance decreased with:

- Increases in sediment shear strength. cohesiveness (e.g., contents of clay) and consolidation;
- Increases in organic content (peat); and
- Increases in particle size (e.g., gravels, cobbles).

~~4.6.238~~4.6.231 Systems can achieve burial in excess of 3 m in soft clays and fine sands, while in medium to coarse sands, the burial depth achieved depends on the grain size of the sediment (i.e., on the re-sedimentation velocity). Any trench remaining after re-sedimentation is left to backfill naturally as a result of the natural movement of sediment on the seabed.

Mechanical trenching

~~4.6.239~~4.6.232 Mechanical trenchers are usually mounted on tracked vehicles and use chains or toothed wheels to cut a trench. They are effective in a range of sediments, including weathered softer bedrock and very soft sediment. However, they are less effective in certain types of rock (e.g., chalk with flints), large gravel, glacial till or boulder clays.

~~4.6.240~~4.6.233 The mechanical trencher follows the cables that have been pre-laid on the seabed, collects them, keeping them clear of active trenching, before guiding the cables into the trench and backfilling sediment on top of the cable. The backfill material and suspended sediment stays in the direct area of the mechanical trencher and the backfilled trench. In some instances, they may be used to create a pre-lay trench into which the cable is laid.

Mass flow excavators (MFE)

~~4.6.241~~4.6.234 MFE may be used for the excavation of the HDD exit pits, sand wave lowering, plough backfill and burial of joints, as well as to increase the depth of lowing (DOL), discussed below in Plate 4.5, in sections with medium to coarse sands, where achieved trenching depths using other methods may not meet the minimum depth of lowering. MFE uses low-pressure water to fluidise the seabed around the cable, allowing the cable to sink into the sediment under its own weight. In medium to coarse sand, MFE creates a depression with fluidised sediment as it moves over the cable. The majority of the fluidised sediment re-settles to the rear of the operation, thus backfilling the trench and covering cable. In fine sand and silt, MFE leaves behind an open trench with very little cover on the cable. Turbidity within the water column as a result of MFE in medium to coarse sand is comparable to that of jet trenching. Suspended sediment stays in the direct area of the operations and either re-settles into the created depression or in its direct vicinity. The seabed footprint of MFE may create a depression up to 10 m wide.

~~4.6.242~~4.6.235 Table 4.14 provides a summary of cable trenching activities.

Table 4.14 Summary of cable trenching activities

Method	Maximum equipment lateral footprint (m)	Total footprint (m^2)	Total footprint (km^2)
Displacement Plough	Width of disturbance per trench – 10 m–25 m. Unlikely to be used	-	-
Jet Plough	Width of disturbance per trench – 8 m–20 m. Length - Unlikely to be used	-	-
Jet Trencher	Width of disturbance per trench – 6 m–12 m. Length up to 43.5 km.	520,000	0.52
Mechanical Trencher (chain cutter)	Width of disturbance per trench – 5 m–15 m. Length up to 59 km.	885,000	0.88
Mechanical trencher (Cutting Wheel – Bedrock)	Width of disturbance per trench – 5 m–15 m. Length up to 16 km.	240,000	0.24

Method	Maximum equipment lateral footprint (m)	Total footprint (m^2)	Total footprint (km^2)
Mass Flow Excavator	Width of disturbance – up to 5 m. Length ~ TBC once contractor is onboard – remedial protection option.	-	-
Controlled Flow Excavator	Width of disturbance – up to 5 m. Length ~ TBC once contractor is onboard – remedial protection option.	-	-
Areas where multiple options could be deployed	Width of disturbance – up to 20 m. Length up to 47 km.	940,000	0.94

~~4.6.243~~4.6.236 The minimum depth of lowering (DOL) to the top of the cable is 0.5 m (in areas of bedrock), with a target DOL for the Proposed Project approximately 1 m–2.5 m, to be achieved where possible dependent on the seabed geology. The trench profile would be deep and narrow, to optimise protection by the trench walls and the *in-situ* soils characteristics. This is best achieved in cohesive clay soils, such as found along the majority of the route.

~~4.6.244~~4.6.237 A Non-Mobile Reference Level (NMRL) (Plate 4.4) would be deduced by the contractor where necessary along the planned cable route, during the detailed engineering phase of the project. The NMRL is the vertical reference which takes all seabed mobility (e.g. ripples, mega ripples and mobile sand waves) along the route into account and represents the top of the so-called “stable” seabed level over the lifetime of the project.

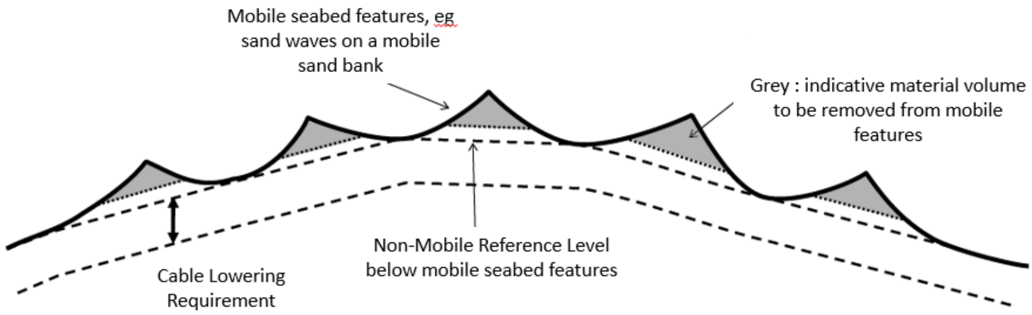


Plate 4.4 Non-Mobile Reference Level

~~4.6.245~~4.6.238 The high-level factors determining the proposed TDOLs are as follows:

- Anchor Strike Risk (ASR); the DOL in areas where there is the highest ASR the recommended DOL is derived to be deeper than the Anchor penetration. This varies on the type of sediment found in these areas.

- Vessel traffic, fishing, and marine use; areas where there are higher levels and volumes of traffic, require that the recommended depth of lowering is increased to reduce risk to the cable.

- Sediment types, distribution, and inherent protection capacity; sediment variations along the route require different TDOLs to ensure the in-situ sediment in the area provides protection against external risk. Where the sediment provides poor protection at the minimum recommended TDOL, the depth of lowering is increased.
- Bedrock types, distribution, and inherent protection capacity; narrow trenches in bedrock provide better protection to the cable bundle, so the recommended TDOL can be reduced.
- Environmental conditions (proximity to land, currents, water depth, sediment mobility); removal / redistribution of sediment protection over time.
- 3rd Party Asset crossings and proximity (power and fibre optic cables).
- Burial equipment limitations.
- Base case burial depth has been assessed at 1m within sediment and 0.5m within bedrock. Any burial depths which differ are as a result of the assessment of the high-level factors listed above.

4.6.2464.6.239 The intervals of Target Depth of Lowering (TDOL) across the Offshore Scheme are shown in Table 4.15.

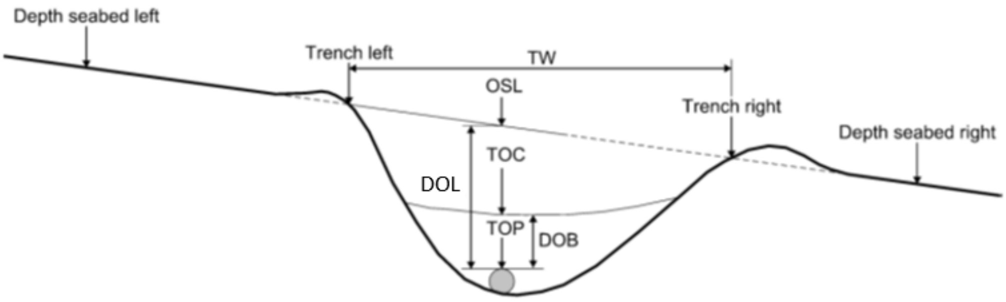
Table 4.15 Target depth of lowering along the Offshore Scheme

Start KP	End KP	Section Distance (km)	Required Cable Burial Depth (m)	Further Detail
0.000	1.524	1.524	N/A	Landfall at Aldeburgh, Suffolk, including trenchless technique requirements.
1.524	6.518	4.994	1.50	
6.518	14.094	7.576	1.00	
14.094	14.410	0.316	1.50	
14.410	15.215	0.805	1.00	
15.215	17.915	2.700	1.50	
17.915	26.342	8.427	1.00	
26.342	31.587	5.245	1.50	
31.587	34.075	2.488	1.00	
34.075	35.089	1.014	1.50	
35.089	38.550	3.461	2.00	
38.550	40.103	1.553	2.50	
40.103	42.806	2.703	2.00	
42.806	43.301	0.495	2.50	
43.301	46.302	3.001	2.00	
46.302	49.828	3.526	2.50	
49.828	54.871	5.043	2.00	
54.871	56.887	2.016	2.50	
56.887	57.887	1.000	2.00	
57.887	68.706	10.819	1.50	
68.706	76.644	7.938	1.00	
76.644	81.301	4.657	1.50	

Start KP	End KP	Section Distance (km)	Required Cable Burial Depth (m)	Further Detail
81.301	85.304	4.003	2.00	
85.304	92.313	7.009	2.50	
92.313	96.343	4.030	2.00	
96.343	113.883	17.540	0.50	Pre-sweep and bedrock across this location means that a depth of 1 m may not be achievable.
113.883	120.469	6.586	1.50	
120.469	121.380	0.911	N/A	Trenchless technique to avoid sensitive habitats at Pegwell Bay landfall.

Trench specifications

4.6.2474.6.240 A representative trench profile is presented in Plate 4.5. The trench profile would ideally be deep and narrow, to optimise protection by the trench walls and the in-situ soils characteristics. This is best achieved in cohesive clay soils, such as found along the majority of the route. However, where the sediments are sand-dominated and loose, the trench walls would slump and the trench profile would rapidly revert to virgin seabed level, or a wide depression would result, to be infilled by natural backfill.



Elevations

OSL: Original Seabed Level. Average of undisturbed seabed left and undisturbed seabed right.
TOP : Top of Product (Product = Cable)
TOC : Top of Cover
Definitions
DOL : Depth of Lowering. Vertical distance from OSL to TOP. When the NMRL is applicable, the DOL is measured from the NMRL to TOP
DOB : Depth of Burial. Vertical distance from TOC to TOP
TW = Trench Width. Horizontal distance between trench left and trench right

Plate 4.5 Representative trench specifications

4.6.2484.6.241 Trench widths are presented in Table 4.16.

Table 4.16 Minimum and maximum trench parameters

Item	Min (m)	Max (m)
Trench Width	0.6	1.5
Burial Depth (Depth of Lowering to Top of Cable)	0.5	2.5

Item	Min (m)	Max (m)
Rock Backfill Depth – High-risk areas	1.6 m (2.0 m TDOL)	2.0 m (2.5m TDOL)
Rock Backfill Depth – Non-high-risk areas.	N/A	N/A

External cable protection

KP35-KP58, Sunk and TSS Section

4.6.2494.6.242 Where TDOL cannot be achieved, rock backfill may be required. An overview of the expected areas of rock backfill are presented in **Application Document 6.4.1.4.3 Areas of Rock Backfill**, namely KP 38 to KP 58, and KP 81.5 to KP 96.5. This section of the route has the highest risk of cable strike, is the busiest section for marine traffic. It is therefore recommended that the trench at this KP range is backfilled using rock (below the original seabed level) along its entire length at the earliest opportunity.

Remedial works

4.6.2504.6.243 For all sections of the route (with the exception of the high-risk intervals KP 35 to 58 and KP 81.5 to KP 96.5), guard vessels would remain on station from cable lay until trenching operations are completed and the cable trench would be subject to monitoring surveys to assess the rate of trench backfill, by natural processes.

4.6.2514.6.244 For areas where suitable backfill has been achieved, the guard vessel would be released. For areas of insufficient backfill, Sea Link would have the decision to either re-survey or instruct remedial works.

4.6.2524.6.245 Indicative contingency for remedial rock protection is 15% of non-high-risk length (excluding trenchless solutions at landfall).

4.6.2534.6.246 Such remedial works may include:

- rock placement; and
- controlled Flow Excavation (CFE), to collapse the trench walls to achieve backfill.

4.6.2544.6.247 Table 4.17 provides an indicative summary of rock placement parameters.

Table 4.17 Summary of back fill and remedial rock protection

Parameter	Description
Remedial rock berm dimensions	Partial lowering: 0.5 m (H) x 1.0 m (top) x 4.0 m (base), 1:3 slope. No lowering: 1.0 m (H) x 1.0 m (top) 7.0 m (base) with 1:3 slope.
Total length of remedial rock berms	Remedial rock berms are to be established as per monitoring surveys where natural back fill has not been sufficiently rapid for the section of route. Indicative contingency as 15% of non-high-risk length (excluding trenchless solutions at landfall). Estimated Length: 12,000 m

Parameter	Description
Total volume of remedial rock berms	Partial Lowering: 24,000m^3 No Lowering: 48,000m^3
Total area of remedial rock berms	Partial Lowering: 48,000m^2 No Lowering: 84,000m^2
Total length of rock backfill in high-risk trench areas	KP 35 to KP 58 KP 81.5 to KP 96.5 38,000 m
Total area of rock backfill in High Risk trench areas	17,100 m^2 (Below the original seabed level)
Total volume of rock backfill in High Risk trench areas	34,200 m^3 (Below the original seabed level)
Total number of rock bags/mattresses	Assumed to be five per HDD exit, both landfall points.

Cable and pipeline crossings

4.6.2554.6.248 There are ten marine in-service power and fibre optic crossings as summarised in Table 4.18 below. The table also contains the onshore crossing locations for Nemo Link and Thanet which would be crossed by passing under the existing asset via trenchless solution such as HDD along with other onshore utilities.

Table 4.18 Summary of in-service crossings

KP	Name	Owner	Type	Status
8.365	Farland (North)	BT	FO Cable	In service
13.373	EA1_N	Scottish Power Renewables	Power	In service
13.769	EA1_S	Scottish Power Renewables	Power	In service
87.306	Britned	BritNed	Power	In service
90.74	Mercator	BT	FO Cable	In service
104.591	PEC	Lumen	FO Cable	In service
106.747	Tangerine	Lumen	FO Cable	In service
107.594	Thanet_N	Balfour Beatty	Power	In service - offshore (northern cable)
107.647	Thanet_S	Balfour Beatty	Power	In service-offshore (southern cable)

113.106	Nemo_Off	Nemo Link	Power	In service – offshore
120.86	Nemo_Onshore_1	Nemo Link	Power	In service – onshore cable #1
120.861	Nemo_Onshore_2	Nemo Link	Power	In service – onshore cable#2
120.885	Thanet Onshore	Balfour Beatty	Power	In service - onshore

~~4.6.256~~4.6.249 In addition to the above in-service power and fibre optic cables, Table 4.19 below also lists the nine known developments also likely to cross the Offshore Scheme but at this stage, specific locations are unknown. Note that the two planned interconnectors indicated at the foot of the table have been notified by OFGEM, but the proposed corridors are unknown but given the landing points these links would cross the Sea Link route.

Table 4.19 Summary of future developments

KP	Name	Owner	Type	Status
11.354	EA3_N_Corr	Scottish Power Renewables	Power	Planned Corridor (northern limit)
14.482	EA3_S_Corr	Scottish Power Renewables	Power	Planned Corridor (southern limit)
50.181	FiveEstuaries_N_Corr	RWE	Power	Planned Corridor (northern limit)
50.672	NeuConnectRPLRev6	Neuconnect	Power	Planned Route
52.012	NorthFalls_N_Corr	SSE/RWE	Power	Planned Corridor (northern limit)
52.719	FiveEstuaries_S_Corr	RWE	Power	Planned Corridor (southern limit)
53.032	NorthFalls_S_Corr	SSE/RWE	Power	Planned Corridor (southern limit)
88.646	Nautilus_Opt1	NGV	Power	Planned
100.151	Q&E North	Consortium	FO Cable	To be installed 2024/2025
101.27	Grid Link	Icon	Power	Planned
Unknown	Cronos Interconnector	Cronos Energy Ltd	Power	Early phase
Unknown	Tarchon Interconnector	Tarchon Energy Ltd	Power	Early phase

4.6.2574.6.250 Sea Link would enter into crossing agreements and/or proximity agreements with the third-party asset owners of any subsea infrastructure installed and/or planned along the corridor. Power, telecom and fibre optic cables would be crossed by the HVDC cables; these cables would be both In-Service (IS) and OOS. Crossings of IS cables would be undertaken using agreed crossing designs in accordance with the crossing agreements with the third-party owners and would ensure separation between the assets and protection over the installed HVDC cables. The separation and protection structures may comprise concrete mattresses, protective sleeves on the HVDC cables and/or pre- and post-lay rock placement. OOS cables may be cleared prior to installation of the cables, thus removing the need for a crossing structure.

4.6.2584.6.251 No pipelines currently cross the Offshore Scheme. However, the same principle would be applied to any future pipelines that may cross the HVDC cables, where the pipeline owner would be responsible for crossing installation.

Table 4.20 Summary of crossings

Aspect	Description
No. of assets to be crossed: In – Service	10 (marine)
No. of assets to be crossed: Planned / proposed	9 systems (Note: number of cables per asset of planned export and interconnectors to be confirmed)
Pipeline crossing	No pipeline crossings on the route or planned pipeline crossings to date.
Height, width and slope of rock berm (pre-lay berms)	0.5 m (H) x 1.0 m (top) x 4.0 m (base), 1:3 slope
Height, width and slope of rock berm (post-lay berms)	1.0 m (H) x 1.0 m (top) x 7.0 m (base) with 1:3 slope. - no pre-lay berm 1.0 m (H) x 1.0 m (top) 10.0 m (base) with 1:3 slope. - includes pre-lay berm
Maximum Length of post-lay berms	500 m (+/- 250 m)
Grade of material	1” to 5” (2” to 8” in areas where hydrodynamics may determine coarser material required, or capping layer)
Cable crossings	Maximum footprint per crossing – 5,000 m^2 Total volume of post-lay rock berms - 500,000m^3 Total footprint of all 10 in-service crossings – 50,000 m^2 (Potential for additional footprint of up to 9 planned crossings – 45 000 m^2) Crossing length: Up to 500 m (+/- 250 m) Crossing width: Up to 10 m Crossing height: Up to 1.5 m Note: where specialised structures may be required, such as shallow water areas, an alternate design may be co-engineered by the 3rd Party Asset Owner and National Grid.

Aspect	Description
Height, width and length of mattresses	0.3 m x 3.0 m x 6.0 m or 0.45 m x 3.0 m x 6.0 m (dependant on specific Crossing Agreements).
Height, width and length of rock bags	0.6 m x 4 m x 4 m
Total length of mattresses	Up to 0.12 km (5 crossings in shallow waters south of the Offshore Scheme - Thanet North, Thanet South, Nemo Offshore, Tangerine and PEC).
Total area of mattresses	Up to 720 m^2

Post installation survey and reporting

~~4.6.259~~4.6.252 During operation the HVDC link would transmit electricity from the proposed Friston Substation to the existing network in Kent and vice versa depending on the supply and demand at the time.

~~4.6.260~~4.6.253 During the lifetime of the link, scheduled monitoring of the system would be undertaken via:

- Electrical testing and monitoring of system.
- Depth of Lowering assessment by planned surveys comprising General Visual Inspection (GVI), bathymetric survey (MBES) and buried cable detection (cable tracker) to chart the cable depth of lowering over time.
- Surveys of crossings with 3rd Party subsea assets, as per requirements in separate crossing agreements per asset.
- Surveys of new asset crossings / proximity zones when new structures are installed crossing over the Sea Link route.
- DTAS (Digital Temperature and Acoustic Sensing) HVDC status monitoring via fibre optic cable (innovative *in-situ* monitoring of cable via near real-time temperature and acoustic monitoring which can inform of changes to the cable by intrusive contact as well as variations in depth of burial dependant on thermal changes on the baseline conditions).

~~4.6.261~~4.6.254 A preliminary inspection, maintenance and repair (IMR) programme as the basis for preventative maintenance may comprise of the following:

- Base-line as-built DOL survey (ideally a continuous survey after installation and protection completed).
- Initial DOL monitoring survey 12 months after commissioning and handover to operations.
- Regular monitoring surveys at 12-24 months duration to establish any areas where DOL hot spots may develop and where integrity of cable is critical (eg. shipping channels, crossings), and inform the maintenance programme. Establish that the seabed conditions and DOL have reverted to equilibrium and reduce the frequency of inspections.

- Reduced interval surveys to ensure DOL is maintained (may be as much as 5-year interval).
- Potential DTAS HVDC cable monitoring via fibre optic cable with near real-time monitoring. As changes occur through time, these can be used as locators of potential seabed change resulting in heat changes, or areas where increase in vessel traffic through the lifetime of the asset may make the link more vulnerable to damage than was risked during the original design of the cable route (e.g. expansion in shipping channel network, or future crossing point for 3rd party asset). The DTAS HVDC cable monitoring would be carried out from the onshore converter stations, but the results would be used to inform the IMR programme each year, and the repair locations in the event of an outage or significant disruption to the transmission of power along the link.
- AIS vessel monitoring to track any vessels stationery or acting suspiciously in the vicinity of the cable.

4.7 Testing and Commissioning

4.7.1 This section gives an overview about testing and commissioning applicable to a HV system, which involve testing of various equipment and sub-systems to verify the design, functional as well as performance aspects of the system. In general, there are three major aspects to the testing and commissioning as follows:

- Design verification of HVDC converter station equipment, HVAC substation equipment, HVDC underground cables, HVAC underground cables and AC OHL
- Functional verification of HVDC and HVAC control and protection
- Performance verification of HVDC and HVAC systems.

4.7.2 Design and functional verifications take place in factory (or, off-site) whereas performance verification is conducted on-site. Off-site testing is performed to prove suitability of the equipment and sub-systems (including C&P system) against design, environmental and network parameters whereas commissioning tests are performed after the equipment and sub-systems have been delivered to site and installed to check overall performance.

4.7.3 Off-site test activities are primarily made up of the following:

- Component tests
  - Routine tests
  - Type tests
- Control system tests

4.7.4 Component tests are conducted on individual components and sub-systems to prove that all components and sub-systems have been properly designed to sustain the stresses during operation. These tests are carried out in accordance with applicable industry-wide standards such as IEC, IEEE, CIGRE, ANSI etc. with some level of adaptation as agreed between the purchaser and manufacturer, if necessary.

4.7.5 Control system tests are conducted after all components (including redundancy) and their design parameters, along with parts of connected AC networks, are modelled in a real-time simulator to verify functional requirements so as to minimise work on site.

These tests are thorough and extensive checks of the control and protection design, software and hardware functions, and modes of operation under normal and fault conditions, but without the constraints that may be imposed in real-time conditions on site. These tests are also important in a way to run many tests (or, test cases) that are impossible, impractical, risky or expensive to perform on site and their results are often compared against system studies to define or develop commissioning plan for validation on-site.

4.7.6 On-site (commissioning) test activities are primarily made up of the following:

- Pre-commissioning tests
- Subsystem tests
  - Circuitry tests
  - Start-up of auxiliary systems
  - Low voltage injection and energisation tests
- System tests
  - High-voltage energisation tests
  - Converter operational tests
  - Transmission tests
- Trial operation

4.7.7 Pre-commissioning tests mainly consist of inspection, electrical and mechanical tests confined to a single installed unit to check equipment or sub-system is properly installed. Subsystem tests verify the proper circuitry and working of functions such as firing control, gate signals, valve control etc. of a group of interconnected or related equipment in preparation of subsequent energisation or system testing.

4.7.8 System tests involve operation of the HVDC system in conjunction with the connected AC networks to check the proper performance and robustness of the rating including redundancy, voltage withstand, control and protection design in terms of set/reference/measurement points, operating sequences, control modes and dynamic response under different network steady-state as well as fault or disturbed conditions. These tests require coordination with TSOs (transmission system operators) of AC networks to which the HVDC system is connected and therefore, tests with lower impact on the connected AC networks are usually performed first followed by high impact (or, more onerous) tests. These tests carried out in accordance with the pre-requisites defined by the manufacturer and operational procedures along with the safety rules and dispatch instructions agreed with the TSOs.

4.7.9 Trial operation allows the purchaser to operate the integrated system according to its intended purpose from the normal control location. It does not start until almost all system tests have been successfully completed. During trial operation, the complete HV system is monitored/observed with alarms or abnormal conditions being dealt as required. Trial operation is also often used to record hot-spot temperatures, power losses, interference levels and audible noise readings to confirm acceptance of the design in accordance with the design limits and subsequent take-over by the purchaser.

4.7.10 Upon completion of all construction activities and handover of the HV system by the contractor following completion of testing and commissioning, the site would be demobilised, final landscaping/planting undertaken, and temporary areas returned to the original condition.

4.8 Construction Waste

4.8.1 Site waste shall be managed in a structured and auditable manner in accordance with the agreed materials and waste management plan (MWMP), from the commencement of the Proposed Project, during the detailed design stage and through construction. This ensures that the aim of waste minimisation is emphasised from the outset. In addition, it would ensure that the waste produced during the construction phase is dealt with in accordance with the relevant requirements of UK legislation, as well as any other requirements specified by the relevant regulatory authorities.

4.8.2 The following main activities that would lead to waste being generated have been identified:

- Wastes arising from earthworks and excavation;
- Wastes arising from construction;
- Wastes arising from office and admin functions; and
- Wastes arising from plant maintenance.

4.8.3 A waste management storage area would be designated as part of the compound to facilitate the segregation of waste. This area would be delineated and separated from where new material is stored, with recycling and waste bins kept clean and clearly marked in order to avoid cross-contamination of materials.

Material Re-Use

4.8.4 During earthworks activities, material would be segregated following excavation to better enable its re-use. Topsoil would be removed first and stored separately to deeper sub-soil. This would enable the material to be re-used as topsoil during reinstatement.

4.8.5 Material excavated as part of the underground cable installation would be re-used as backfill within the trenches if deemed to have suitable thermal properties to comply with the proposed cable system design.

4.8.6 Excess sub-soil and top-soil would be used as part of the landscaping works where viable limiting the need to remove it from site.

4.9 Operation

Proposed Friston and Minster 400kV Substations

4.9.1 The proposed substations would be operated by a small team but would not be staffed continuously. The substations would be continuously monitored remotely by National Grid, with regular monthly visits to inspect the site.

4.9.2 Unlike the construction phase, no material is consumed, or machinery required during operation.

Proposed Converter Stations

4.9.3 Following a period of commissioning and testing (as described above) the proposed converter stations would operate continuously throughout the year. Whether each end is (converting DC to AC) or (converting AC to DC) would depend on supply and demand on the transmission system.

4.9.4 The proposed converter stations would be operated by a small team based on site. In general, a minimum of two operators would be present at all times. During normal operation there would be approximately six personnel on site, divided between three shifts over a 24-hour period.

4.9.5 Unlike the construction phase, no material is consumed, or machinery required during operation.

Proposed Overhead HVAC Connection

4.9.6 During operation the overhead line in Kent would transmit electricity from the proposed Minster 400 kV substation onto the existing network in the South East of England.

4.9.7 The overhead lines would not require daily attendance from operators. No material is consumed, or machinery required during operation.

Proposed Underground HVAC and HVDC Cables

4.9.8 During operation the HVDC link would transmit electricity from the proposed Friston Substation in Suffolk to the existing network in Kent and vice versa depending on the supply and demand at the time.

4.9.9 The underground cables would not require daily attendance from operators. No material is consumed, or machinery required during operation.

Noise

4.9.10 The outline noise parameters for the Suffolk Onshore Scheme and Kent Onshore Scheme are provided in the operational noise assessment appendices as set out below.

4.9.11 The noise source data for normal operation of Saxmundham Converter Station is provided in Table 1.4 of **Application Document 6.3.2.9.D Part 2 Suffolk Chapter 9 Appendix 2.9.D Suffolk Operational Noise Assessment**.

4.9.12 There would be no sources of noise during the normal operation of the Friston Substation because there are no transformers proposed, which are typically the only source of noise at such sites. There would, however, be a backup generator, and gas insulated switchgear (GIS), with noise information provided in **Application Document 6.3.2.9.E Part 2 Suffolk Chapter 9 Appendix 2.9.E Suffolk Friston Substation and OHL Operational Noise Information (Informative).**

4.9.13 The noise source data for normal operation of Minster Converter Station and Substation is set out in Table 1.4 of **Application Document 6.3.3.9.D Part 3 Kent Chapter 9 Appendix 3.9.D Kent Operational Noise Assessment**.

Proposed Marine Cable

4.9.14 The Offshore Scheme is designed for a lifespan of approximately 40-60 years. The main operation requirement is for regular monitoring surveys along the installed cable route, which use visual (GVI), where visibility and sensors allow, bathymetric and depth of lowering (cable tracker) data to compare against the baseline survey data. The survey would require high resolution data to be acquired, for use in analysis software for time-series analyses of the seabed changes along the cable route.

4.9.15 The same equipment spread may be utilised for crossing surveys to comply with 3rd Party Asset inspection requirements, and could be undertaken at the same time, or under an independent mobilisation, as required.

4.9.16 As the use of autonomous vehicles for non-intrusive surveys is adopted by the industry, the surveys may be carried out using a range of autonomous surface vehicles (ASVs) and / or autonomous underwater vehicles (AUVs) which reduce the size of any support vessel and allow frequent surveys to be undertaken over the continuous route, or sections of interest. Developments are underway to have ROVs deployed from ASVs which would also allow GVI activities to be carried out with a smaller support vessel and manning levels, as well as less environmental impact. The support vessel would require to be suitable for the operations to be carried out with regard to metocean conditions and marine traffic levels, in full compliance with marine legislation for autonomous vessels.

4.9.17 Providing a comprehensive DOL survey is carried out as the final 'as-built' survey, subsequent intermediate surveys may comprise, for instance, of an ASV running along the route using MBES in order to compare and monitor any changes in seabed level (and hence cover over the cable), thus providing a quick and easy monitoring regime. A full survey recording DOL would be required at regular intervals, especially in higher risk areas where the DOL is critical to the protection of the cable (e.g. shipping channels and close to anchorages).

Marine emissions

4.9.18 There are several emissions which may occur during the construction, operation and decommissioning phases:

- Electric and magnetic fields (EMF);
- Heat; and
- Underwater sound.

Electric and magnetic fields

4.9.19 Electric and magnetic fields (EMF) are generated when electrically charged particles are accelerated. EMF occurs naturally in the marine environment and may be defined as follows:

- Magnetic Field: A bundled arrangement is being considered for the Offshore Scheme. The strength of the magnetic field produced by the cable would depend on the current flowing in the cables, the separation of the cables and the distance from the cables.
- Electric Field (E field): The cables themselves emit no external electric field as the E field is contained within the metallic outer sheath of the cable.
- Induced Electric Field (iE field): iE field are induced in the sea water as it passes through the geo-magnetic field. The strength of these fields is dependent on the geo-magnetic field strength and sea water chemistry, viscosity, its flow velocity and direction to the direction of the geo-magnetic field.

4.9.20 Naturally occurring induced electric fields also occur and for the North Sea have been measured at 35 µV/m (Pals, Peters, & Schoenhage, 1982). Given the background EMF levels, the induced electric fields could range between 24.5 µV/m and 61.3 µV/m (Tripp, 2016). However, the strength of the electric field in the sea varies continuously because of the varying speeds and directions of the water flow that are consequences of the tides and weather conditions, but it is essentially a static field.

Magnetic fields

4.9.21 The majority of the offshore route would be installed as a bundled bipole, meaning the two cables are installed together, touching one another. The cable manufacturer is yet to be determined, but a standard diameter of 0.137m for each cable was used for the calculations. Burial depth would depend on seabed composition. Where cables are buried in sediment, burial depth would range between 1.0 – 2.5 m and where bedrock is present cables would be buried at 0.5 m depth.

4.9.22 Where the offshore cables transition on to land, HDD or a trenchless solution would be used as the installation technique. This technique results in the cables separating but getting deeper, then progressively becoming closer together. The maximum separation distance of 4 5m and burial depth of 10 m were taken to represent a worst-case situation. Both the bundled and trenchless installation techniques have been considered.

4.9.23 The HVDC cables would operate at ±525 kV carrying 2 GW of power. The maximum current rating of the cables has been used for all calculations.

4.9.24 All calculations were performed assuming maximum circuit separation and minimum burial depth, giving a worst-case scenario at maximum 100 % rating. The maximum magnetic field for each different installation technique was calculated at vertical distances of 0 to 50 meters from the seabed, and horizontal drop off along the seabed. For bundled cable installation a worst-case (minimum) burial depth of 0.5 m was used to represent areas where bedrock is present and 1.0 – 2.5 m depth if located in sediment.

4.9.25 Calculation results can be found in Table 4.21, giving the maximum magnetic field at vertical distances from the cables for all installation methods and depths.

Table 4.21 Calculated maximum cable magnetic fields at vertical distances from the seabed for the offshore Sea Link cable circuit options

	Magnetic fields (µT)						
	Distance above seabed (m)						
	Seabed	**0.5**	**1**	**2**	**5**	**10**	**20**
Bundled: 0.5 m depth	204.9	52.0	23.3	8.4	1.7	0.47	0.12
Bundled: 1.0 m depth	51.5	23.2	12.9	5.8	1.44	0.43	0.12
Bundled: 1.5 m depth	23.2	13.0	8.4	4.3	1.2	0.39	0.11
Bundled: 2.5 m depth	8.3	5.8	4.2	2.6	0.92	0.33	0.10
Trenchless	38.1	36.3	34.6	25.4	25.4	19.1	12.2

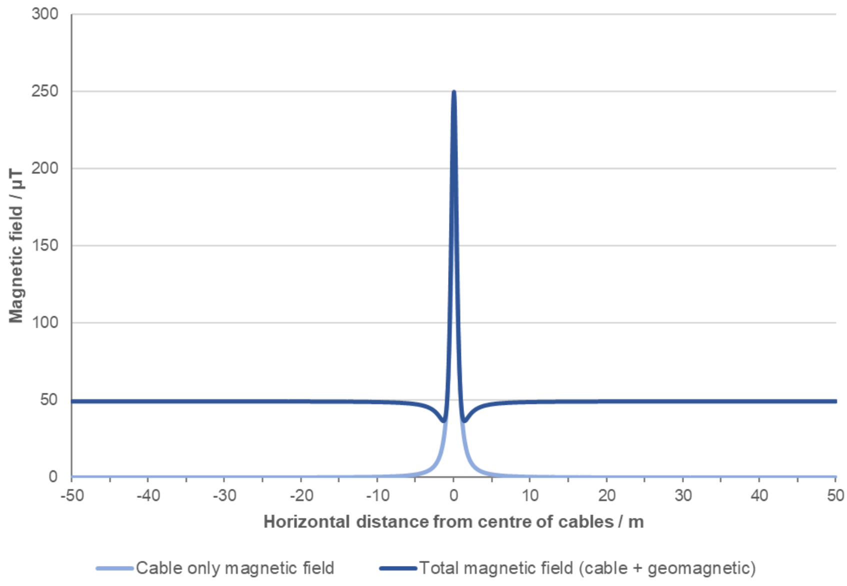


Plate 4.6 Calculated maximum magnetic fields horizontally along the seabed for bundled cables, 0.5 m depth. The light blue line shows the maximum magnetic field from the cables only. The dark blue line shows the total magnetic field when combined with the earths geomagnetic field.

4.9.26 The calculated magnetic fields are greatest on the seabed and reduce rapidly with vertical and horizontal distance from the circuits. The highest magnetic fields were observed when the burial depth of the cables was shallowest. Irrespective of the burial depth the magnetic fields reduce rapidly with distance from the cables due to bundling of the cables. The maximum magnetic fields calculated for cables buried 0.5 m deep and at the seabed were 204.9 µT compared to 8.3 µT when cables were buried 2.5 m deep.

Induced electrical fields

4.9.27 The magnetic field produced by the cable decreases with distance from the cables. The movement of the sea, as a result of tidal currents, through the magnetic field results in a small localised electric field being produced, the induced electric field (iE), although the cable shielding would restrict the transmission of electric fields. A background electric field would also be present in the sea due to the geo-magnetic field and localised magnetic anomalies.

4.9.28 The convention for calculating induced electric fields applied to comparable projects including Basslink, BritNed HVDC and Western Link connections is:

Induced electric field (pV/m) = Velocity (m/s) x Magnetic field (pT)

4.9.29 This is a vector cross product which means that the strength of the electric field is proportional to the component of the velocity perpendicular to the magnetic field and is in a direction perpendicular to both. The tidal velocities for the Proposed Project are evaluated for values up to 4 knots, to represent a very worst-case situation.

4.9.30 The average geomagnetic field along the Sea Link route is approximately 49 μT, which is used for the calculations of background induced electric field. This background magnetic field induces an electric field that could range between 49 and 101 μV/m in tidal velocities ranging between 0.5 and 4 knots. This does not take account of localised magnetic anomalies, which could result in higher localised electric fields, or of greater tidal velocities. The induced electric field under a range of tidal velocities is shown in Table 4.22.

4.9.31 These simplistic calculations are an overestimate of the induced electric field present close to the seabed. Water velocity distribution is non uniform due to friction that occurs at the seabed, where the magnetic field is greatest, which would reduce the resulting induced electric field.

Table 4.22 Calculated induced electric field

		Induced electric field (μV/m)					
			Tidal Velocity (knots)				
	Distance above seabed	Magnetic field (μT)	0.5	1	2	3	4
Bundled: 0.5 m depth	Seabed	204.9	53.3	104.5	211.1	315.6	422.2
	0.5m	51.2	13.5	26.5	53.5	80.0	107.0
	1 m	23.2	6.0	11.8	23.8	35.7	47.7
	5 m	1.7	0.45	0.88	1.8	2.7	3.6
	10 m	0.47	0.12	0.24	0.49	0.73	0.98
	20 m	0.12	0.03	0.06	0.13	0.19	0.26
Bundled: 1.0 m depth	Seabed	51.6	13.4	26.3	53.1	79.4	106.2
	0.5m	23.2	6.0	11.8	23.8	35.7	47.7
	1 m	12.9	3.4	6.6	13.3	19.9	26.7
	5 m	1.4	0.37	0.73	1.5	2.2	3.0
	10 m	0.43	0.11	0.22	0.44	0.66	0.88
	20 m	0.12	0.03	0.06	0.12	0.18	0.24
Bundled: 1.5 m depth	Seabed	23.2	6.0	11.8	23.8	35.7	47.7
	0.5m	13.0	3.3	6.7	13.4	20.1	26.8
	1 m	8.4	2.2	4.3	8.6	12.9	17.2
	5 m	1.2	0.32	0.63	1.3	1.9	2.5
	10 m	0.39	0.10	0.20	0.41	0.61	0.81

	Induced electric field (µV/m)						
			Tidal Velocity (knots)				
	Distance above seabed	**Magnetic field (µT)**	**0.5**	**1**	**2**	**3**	**4**
	20 m	0.11	0.03	0.12	0.12	0.17	0.23
Bundled: 2.5 m depth	Seabed	8.3	2.2	4.2	8.5	12.8	17.1
	0.5 m	5.8	1.5	2.9	5.9	8.9	11.9
	1 m	4.2	1.1	2.2	4.6	6.5	8.7
	5 m	0.92	0.24	0.47	0.95	1.4	1.9
	10 m	0.33	0.09	0.17	0.34	0.51	0.68
	20 m	0.10	0.03	0.05	0.11	0.16	0.21
Trenchless	Seabed	38.1	9.9	19.4	39.2	58.7	78.5
	0.5 m	36.3	9.4	18.5	37.4	55.6	74.7
	1 m	34.6	9.0	17.7	35.7	53.4	71.4
	5 m	25.4	6.6	13.0	26.2	39.1	52.3
	10 m	19.1	5.0	9.7	19.6	29.3	39.2
	20 m	12.2	3.2	6.2	12.6	18.8	25.1

Magnetic compass deviation

4.9.32 A Compass Deviation Assessment has been undertaken for the Offshore Scheme. The magnetic fields from the cables would combine with the Earth's magnetic field and can cause a magnetic compass to indicate north in a different direction to the magnetic north pole, referred to as compass deviation. Current advice from the Maritime and Coastguard Agency states that they would be willing to accept a three-degree deviation for 95% of the length of the Marine Scheme and for the remaining 5%, no more than five-degrees of deviation.

4.9.33 Very low compass deviation occurs over the majority of the route. The bundled cable design achieves less than 3º compass deviation, and less than 5º compass deviation for 99.3 %, meeting the MMO compass requirements.

Heat

4.9.34 The process by which submarine power cables and other imperfect conductors generate heat is termed resistive heating. It is caused by energy loss as electric current flows and leads to the heating of the cable surface and warming of the surrounding environment.

4.9.35 The use of high voltages minimises heat losses and resultant environmental warming effects because current loads are relatively small. Additionally, HVDC systems result in comparatively less heat loss to the environment for a given transmission rate than AC cables (OSPAR, 2009) such that relatively smaller environmental heating effects would be expected for a given power transmission.

4.9.36 Where submarine power cables are buried, the surrounding sediment may be heated but cables, whether buried or not, have negligible capability to heat the overlying water column because of the very high heat capacity of water.

4.9.37 Plate 4.7 provides an indicative temperature distribution profile for bundled cables trenched to a depth of 1.5 m, where the ambient seabed maximum temperature has been assumed to be 15°C. Plate 4.7 suggests that where the minimum depth of lowering of approximately 0.5 m is achieved, the temperature increase at the seabed surface is expected to be approximately 5°C.

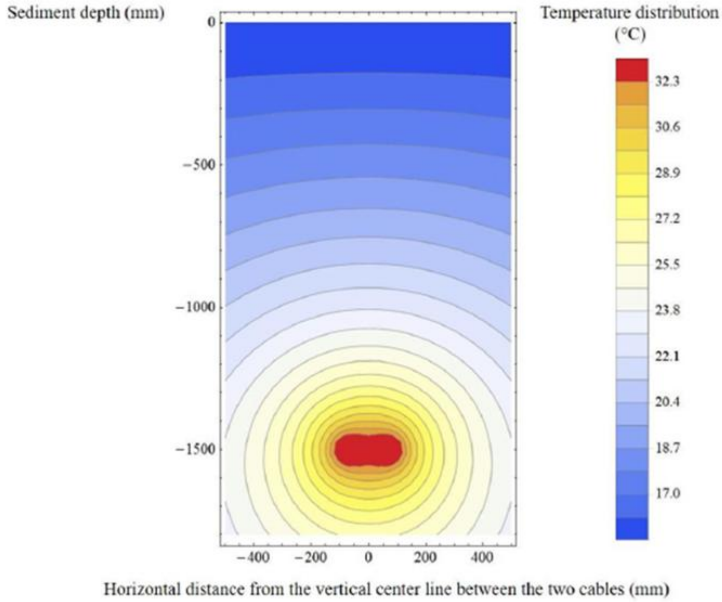


Plate 4.7 Temperature distribution in the vicinity of a bundled pair of 1800 mm2 Cu SPLE cables operated at +/-515 kV.

Underwater sound

4.9.38 The predominant noise generating activities are:

- Geophysical survey equipment (e.g., multi-beam echo sounder (MBES), sidescan sonar (SSS), sub-bottom profiler SBP) and ultra short baseline (USBL) acoustic positioning;
- Cable trenching, mechanical cutting and MFE;
- Placement of rock protection or concrete mattresses;
- Vessels using DP; and
- Support vessels (non-DP).

4.9.39 The activities include examples of both impulsive and non-impulsive (or continuous) sound sources. Impulsive sound, such as that generated by geophysical survey equipment, is characterised by short duration pulses (<1 second), these sounds have a broadband bandwidth have a rapid rise and decay period with a high peak pressure. In contrast non-impulsive sound, such as generated by vessel movements and dynamic positioning, do not have rapid rise and decay times or a high peak pressure.

Background noise context

4.9.40 Underwater sound produced by the Proposed Project must be considered against a background of noise produced by other human activities in the area, and in particular, shipping. These ships include merchant vessels, tankers and ferries, fishing vessels and offshore industry support vessels.

4.9.41 Underwater sound in the North Sea is dominated by shipping sounds. Total underwater sound levels, from both shipping and natural sound range from 105 dB to 130 dB re 1 µPa Sound Pressure Level (SPL) and are significantly higher than natural noise levels (Joint Monitoring Programme for Ambient Noise North Sea, 2022). Ambient underwater sound is high in the southern part of the North Sea, including in the Humber region and towards the English Channel.

Geophysical survey

4.9.42 Table 4.23 provides typical acoustic properties associated with the survey techniques that may be required during geophysical surveys.

Table 4.23 Acoustic properties of indicative survey equipment

Sound Source	Example Equipment	Frequency (kHz)	Maximum Sound Source Level (SPLPEAK dB re 1 µPa @1m)
Multibeam echo sounder (MBES)	Kongsberg Maritime EM 2040 Dual Rx system	170-450	221
Side scan sonar (SSS)	Edgetech FS4200 SP (300-600kHz dual frequency)	300-600	210
Sub-bottom profiler (SBP)	Innomar SES-2000, Edgetech Chirp & Applied Acoustics 201 boomer Innomar Medium 100	0.5-12 100	238 238
Ultra-short baseline (USBL)	Kongsberg HiPAP 502	21-31	207

4.10 Maintenance

Proposed Friston and Minster 400kV Substations

4.10.1 Maintenance would be undertaken on an ongoing basis with individual equipment subject to a three-year maintenance cycle. Maintenance could include visual and physical inspections plus testing, repairing and replacing substation equipment as necessary. Visual checks would be undertaken on a monthly inspection visit to the site. In the majority of cases inspection would require access to the substation using light goods vehicles (LGVs) and the delivery/removal of a Mobile Elevating Works Platform (MEWP).

4.10.2 If the substation required refurbishment or replacement works, vehicles would be used to carry workers in and out of site and suitable vehicles would be used to bring new materials and equipment to site and remove old equipment.

Proposed Converter Stations

4.10.3 During maintenance (planned and unplanned) the number of personnel present on site would increase with the number of staff proportionate to the nature of the maintenance works being undertaken.

4.10.4 If the converter stations required refurbishment or replacement works, vehicles would be used to carry workers in and out of site and suitable vehicles would be used to bring new materials and equipment to site and remove old equipment.

Proposed Overhead HVAC Connection

4.10.5 The overhead line would be subject to an annual inspection from the ground or by helicopter/drone. The inspection would identify if there are any visible faults or signs of wear and would also indicate if changes in plant or tree growth or development had occurred that could risk infringing safety clearances. Inspections would provide input as to when refurbishment was required.

4.10.6 The overhead line could support telecommunication equipment such as small mobile telephone antennae and would contain optical fibres within the earthwire. If this were to be the case, independent companies would require access for maintenance purposes using pickup trucks and vans. Access for the optical fibres would usually be at the joint box positions located just above the anticlimbing devices on certain pylons. Position and frequency of joint boxes is subject to design by the successful contractor.

4.10.7 Access for vegetation management, telecommunications and fibre optic maintenance would be along routes agreed with the landowners and may require interlocking track mat panels.

4.10.8 The overhead line would be made up of a variety of materials, including concrete and steel for the foundations, steelwork for the pylon and aluminium for the conductors. All these materials have an expected lifespan, which would vary depending on how the overhead line was used and where it is located. Typically, pylon steelwork and foundations have a life expectancy of approximately 80 years, the conductors have a life expectancy of approximately 40 to 60 years and the insulators and fittings have a life expectancy of approximately 25 to 40 years. The lifespan of the overhead line may be longer than the anticipated 80 years, depending on its condition, the environment to which it is exposed, refurbishments and transmission network requirements.

4.10.9 Minor repairs or modifications may be required from time to time for local earthwire damage, addition of jumper weights, local conductor damage, broken insulator units, damaged or broken spacers, broken or damaged vibration dampers, damaged or broken anti climbing guards. Minor repairs would be programmed locally by a maintenance team using pickup trucks and vans to access site along routes agreed with landowners. Access may require interlocking track mat panels.

4.10.10 Refurbishment work would be undertaken typically on one side of the pylon at a time, so that the other side could be kept 'live' or in use. Refurbishment work could involve:

- the replacement of conductors and earth wires;
- the replacement of insulators and steelwork that holds the
- conductors and insulators in place, insulator fittings and
- conductor fittings;
- painting or replacement of the pylon steelwork and
- replacement of telecommunication equipment (by separate companies).

4.10.11 During refurbishment there would be activity along the overhead line, especially at tension pylons when a new conductor is installed, and an old conductor taken down.

4.10.12 Vans would be used to carry workers in and out of the site and trucks would be used to bring new materials and equipment to site and remove old equipment. Temporary works including access tracks and scaffolding to protect roads may be required as for construction.

Proposed Underground HVAC and HVDC Cables

4.10.13 Maintenance activity along the proposed cable routes would generally be limited to non-intrusive inspections and cable repairs. The latter would only be required in the unlikely event of a cable fault.

4.10.14 Where a fault does occur the location of the fault would be identified, and the faulty section of cable replaced. The activities involved in cable repair would be similar to those outlined above for installation albeit over a much smaller area and scale.

4.10.15 The lifespan of the cables would be 40 years following this replacement may be required if the system design still requires the capacity.

Proposed Marine Cable

4.10.16 The cable system installation is designed such that a regular maintenance regime is not required to maintain the integrity of the link. However, the monitoring surveys described above, and the land based DTAS monitoring may indicate that localised lengths along the cable link may require maintenance. This would normally be in areas of mobile sediment, such as scour or mobile bedforms migrating over the route, which alters the DOL of the cable. Maintenance may be the addition of mattresses, rock or grout bags, installation of remedial rock berms, additional trenching (where appropriate), or the removal of excess sand depth, as mobile bedforms migrate, resulting in excessive DOL. The latter would be undertaken using a Controlled Flow Excavator, or partial deburial methods (eductor).

4.10.17 Cable repairs may be required at any time, however good design and installation would mitigate this. A repair preparedness plan (RPP) would be prepared which details the actions to be taken, from detecting a fault to re-commissioning.

4.10.18 Repairs which occur after commissioning and acceptance of a successful installation and protection project are rare and can usually be attributed to the following:

- Cable technical failure;
- Marine traffic accidental damage such as an anchor strike or fishing gear snagging or entanglement; and
- Third party works.

4.10.19 Where possible a repair agreement would be in place with a marine contractor with provision for a minimum of 5 repair joints and sufficient spare cable to undertake a repair to both HVDC and fibre optic cables in the deepest part of the route.

4.10.20 The marine cable repair requirements for Sea Link are split into three components due to the complexity of the Pegwell Bay nearshore area, comprising mudflats which are exposed for significant parts of the tidal cycle and therefore the complexity of access to any repair site, and the use of trenchless solutions to cross the beach landings.

4.10.21 Prior to any repair scenario, the location of the fault needs to be identified and confirmed from TDR (time domain reflectometry), and OTDR (Optical time domain reflectometry) where the fibre optic cable may be damaged and visual survey of the seabed (where external damage is thought to be the cause of the fault) which may lead to a delay prior to commencing the cable deburial and repair activities.

4.10.22 A spare conduit would be installed at both landfalls (which can accommodate an HVDC or fibre optic cable), so that if there is a cable issue which is deemed to be a high-risk repair, the simplest solution would be to install a new section of cable from offshore to the TJB and cut and splice to the existing cable offshore. An onshore joint would then be carried out at the TJB allowing a relatively rapid repair window. In order to undertake such a repair a typical requirement would be for the following:

Nearshore Pegwell Bay

- Inform marine users of seabed hazard via a Notice to Mariners.
- Inform 3rd Party Asset holders and Stakeholders of damaged cable on mudflats and arrange protected access points over 3rd party assets.
- Notification of exclusion zone to other users in the local area during repair works.
- Onshore repair support to prepare and secure area to assist excavation of buried spare duct bellmouth (e.g. potentially installing coffer dam around the duct bellmouth prior to excavation), if replacement cable to be installed through the spare duct.
- Nearshore barge to allow 24 hour excavation of buried spare duct bellmouth and trench approach as preparation for cable pull-in.
- Onshore preparatory spread for access to marine TJB (transition joint bay) and preparation for pull-in and jointing (if required for replacement cable via the spare duct).
- Onshore repair support to prepare and secure area to assist excavation of damaged cable if this is on the mudflats but does not require utilisation of spare duct.

- CLV/barge with spare cable length for cable pull-in operation and associated equipment spread.
- Repair joint and spread.
- Recovery spread for damaged cable section, if not permitted to remain in-situ until link is decommissioned at end of life.
- Post-repair protection spread.

Offshore

- Inform marine users of seabed hazard via a Notice to Mariners.
- Inform 3rd Party Asset holders in proximity to repair site and any Stakeholders of damaged cable location, including any envelope of error on the location which cannot be confirmed until cable is tested.
- Deployment of a guard vessel to the location and notification of exclusion zone to other marine users in the local area.
- Visual inspection survey and deburial works in deeper water and post lay protection works.
- Cut cable and test to confirm fault location.
- CLV with spare cable length for cable repair and associated joints and repair spread.
- Cable testing facilities.

Suffolk

- Inform marine users of seabed hazard via a Notice to Mariners.
- Deployment of a guard vessel to the location and notification of exclusion zone to other marine users in the local area.
- Nearshore barge to allow divers to excavate buried spare HDD bellmouth and prepare for cable pull-in.
- CLV/barge with spare cable length for cable pull-in operation and associated equipment spread.
- Offshore repair joint and spread.
- Onshore preparatory spread for access to marine TJB and preparation for pull-in and jointing.
- Deburial works in deeper water and post lay protection works.

4.11 Decommissioning

4.11.1 There are no plans to decommission the Proposed Project. Whilst most elements of the Proposed Project have lifespans of approximately 40 years (with the exception of pylons which have a typical lifespan of up to 80 years), these lifespans are likely to be extended given the anticipated increase in electricity demand in the future. The design life of the Proposed Project could be extended with regular maintenance and refurbishment of each component.

4.11.2 In the event that, at some future date, the authorised development, or part of it, is to be decommissioned, a written scheme of decommissioning would be submitted for approval to the relevant planning authority at least six months prior to any decommissioning works, as set out in Requirement 13 in Schedule 3 of **Application Document 3.1 Draft Development Consent Order**. The decommissioning works would follow National Grid's processes at that point in time, for assessing and mitigating any environmental impacts.

4.11.3 Should decommissioning be undertaken, the workforce required for decommissioning of the assets would be lower than the number required during construction with an estimated peak of approximately 150 people required for Kent and 210 people required for Suffolk.

4.11.4 Temporary site compounds and other enabling works would be required during decommissioning similar to that needed during construction. It is anticipated that the temporary site compounds required for decommissioning of the substation and converter station sites would be located in the same location as required during construction. Due to the anticipated reduced workforce required for decommissioning of the overhead line and underground cables, the locations of the temporary construction compounds should be reviewed at the time of decommissioning.

4.11.5 The working hours for decommissioning activities would be similar to those for construction with a total estimated duration of decommissioning of two years.

4.11.6 The requirements for vegetation clearance during decommissioning would be subject to the extent of vegetation present in proximity of assets at the time and can not be accurately predicted at this time.

Proposed Friston and Minster 400kV Substations

4.11.7 The lifespan of substation equipment is approximately 40 years. If the elements of the proposed substations, that form part the Proposed Project were no longer required, the equipment would be safely disconnected from the transmission system and carefully dismantled using cranes.

4.11.8 Much of the material would be taken for recycling. Where this is not possible, removed equipment would be disposed of in accordance with the relevant waste disposal regulations at the time of decommissioning.

4.11.9 Similar methods and equipment would be required for dismantling as for construction.

Proposed Converter Stations

4.11.10 The anticipated operational life of the proposed Saxmundham and Minster Converter Stations is approximately 40 years. It is likely that during this period refurbishment and plant replacement would extend the life of the converter station rather than decommissioning. In the event that the Proposed Project ceases operation the proposed converter stations would be decommissioned in accordance with a decommissioning plan that is expected to include but not limited to as follows:

- Dismantling and removal of equipment;
- Removal of cabling from site;
- Removal of any building services equipment;

- Demolition of the buildings and removal of fences; and
- Landscaping and reinstatement of the site.

4.11.11 The main components would be dismantled and removed for recycling wherever possible. It would also be evaluated whether the buried cables systems could be used for another purpose. Where this is not possible disposal would be undertaken in accordance with the relevant waste disposal regulations at the time of decommissioning. It is anticipated that the permanent access road would be left *in-situ* whereas the above ground features would be removed to a sufficient depth to allow other practices/construction to occur unhindered.

Proposed Overhead HVAC Connection

4.11.12 If the Proposed Project is required to be decommissioned the section of overhead line between the proposed Minster Converter Station site and the existing Richborough to Canterbury 400kV overhead line would be removed. Fittings such as dampers and spacers would be removed from the conductors. The conductors would be cut into manageable lengths or would be winched onto drums in a reverse process to that described for construction. The fittings would be removed from the pylons and lowered to the ground.

4.11.13 Each pylon would most likely be dismantled by crane, with sections cut and lowered to the ground for further dismantling and removal from site. Depending on the access and space available, it may be possible to cut the pylon legs and then pull the pylon to the ground using a tractor. The pylon could be cut into sections on the ground.

4.11.14 Much of the material would be taken for recycling. Where this is not possible, removed equipment would be disposed of in accordance with the relevant waste disposal regulations at the time of decommissioning.

4.11.15 Unless there was a compelling need for removal of all the foundations, these would be removed to approximately 1 m deep, sufficient for safe agricultural use of the land and subsoil and topsoil reinstated.

4.11.16 It is anticipated that any agricultural fields containing OHLs would be returned to agricultural use following decommissioning.

Proposed Underground HVAC and HVDC Cables

4.11.17 If the Proposed Project is required to be decommissioned, the proposed underground cables would be decommissioned. Dependent on specific requirements the redundant cables could either be left *in-situ*, or all or parts of the cable could be removed for recycling. Where this is not possible, removed cables would be disposed of in accordance with the relevant waste disposal regulations at the time of decommissioning.

4.11.18 It is anticipated that the any agricultural fields containing underground cables during operation would be returned to agricultural use following decommissioning.

Proposed Marine Cable

4.11.19 An initial decommissioning plan would be written once the final route and installation methodology is engineered by the contractor post submission. This would be in accordance with all applicable legislation, best practice guidance and Shoreline Management Policies at the time of compilation, however as decommissioning of the cable would be many decades into the future, regulatory requirements and industry best practice may change. Sediment transport studies have been commissioned and undertaken by National Grid which outline the short to long term nearshore beach variance and stability at both landfalls. These studies would be used to inform the initial decommissioning plan.

4.11.20 This initial decommissioning plan would be updated throughout the life of the project in preparation for the eventual decommissioning of the link.

4.11.21 Dependent on requirements at end of asset life, the redundant cables could either be recovered for recycling (in its entirety, or in parts), or left *in-situ*, if that has less environmental impact.

4.11.22 When decommissioning comprises of cable removal, the recovered cables/cable sections would be disposed of in accordance with the relevant waste stream management regulations at the time of decommissioning.

4.11.23 Operations to undertake decommissioning of the cable would be dependent on the burial depth of the cable and the mobility of the seabed, which may have significantly changed the design depth of lowering and the depth of sediment over the cable at the end of asset life.

4.11.24 The techniques for decommissioning are often simpler than for installation prioritising minimising seabed disturbance over cable integrity.

4.11.25 In areas where the cable is shallow buried it may be possible to pull the cable out of the seabed without the use of other equipment. In areas where it is slightly more deeply buried under-running the cable to help free it from the seabed may be a possibility.

4.11.26 The potential removal techniques have a low environmental impact and are only suitable where the cable is not deeply buried. In areas of deeper burial, or mobile seabed, the use of jetting or controlled flow excavation to release the cable from the seabed may be considered.

4.11.27 Any active crossings, at the time of decommissioning, would normally be left in place, with a section of decommissioned cable left *in-situ* for a safe distance from the in-service asset. Similarly, where the cables are in close proximity to other in-service assets, removal of the decommissioned Sea Link cables may not be possible until the other assets are decommissioned.

4.11.28 Removal of the trenchless solutions from the transition joint bay passing under the beach landfalls to the bellmouth exits should be reviewed at the time of decommissioning as it may be less damaging to leave *in-situ* with stabilisation, than to excavate and remove, especially given the sensitivity of both landfall trajectories.

4.12 References

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