The Great Grid Upgrade

Sea Link

Sea Link

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National Grid

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Ground Investigation Report - Suffolk

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Contents

1 Introduction

In the next 10 years, the capacity of interconnectors connecting along the South Coast transmission route from Lovedean to Kemsley is forecast to reach circa 7GW, with a further 4GW at Grain and Kingsnorth. A new High Voltage Direct Current (HVDC) link between Richborough in East Kent and a proposed new substation at Friston, in Suffolk, has been identified by National Grid (NG) as being the optimal solution to increase transfer capacity between the South Coast and South London and maintain voltage at compliance level.

Mott MacDonald Ltd. (MM) have been commissioned by National Grid to act as FEED consultants on the SEA Link project. This includes supporting NG with the delivery through to the Development Consents Order (DCO) submission, decision, and input to the Works Information for the Main Works Tender to the construction phase of the project. The project involves a 2GW HVDC link between Richborough in Kent and Saxmundham in Suffolk which forms part of the solution to resolve the operational boundary issues in the South Coast, East Coast and London Areas.

It should be noted that this report only covers the on-shore elements of the Suffolk part of the wider Sea Link project, with off-shore elements assessed by others. The Kent part of the onshore scheme is assessed within a separate GIR, summarised below:

- Mott MacDonald Limited, Sea Link FEED, Ground Investigation Report – Richborough. Document reference: SEAL-MMD-SEAL-ENG-REP-0693

The landfall horizontal directional drill (HDD) element as well as Friston Substation is not within Mott MacDonald Limited's scope. The scope and this report covers the site to its connection with the landfill HDD at the marine to terrestrial transition joint bay.

1.1 Scope and objectives of the report

The objectives of this report are:

- To review and summarise the project-specific preliminary 'de-risking' ground investigation data, including laboratory test data, for works carried out at the Suffolk site in 2023
- Provide a series of preliminary ground models and geotechnical parameters to inform design development
- Produce a geotechnical risk register outlining the key ground related hazards and risks associated with the ground conditions, and provide ground engineering advice in support of the proposed design

The report has been prepared in accordance with the requirements of BS EN 1997-1.

1.2 Description of the project

1.2.1 Description of the Site

A site location plan is presented in Figure 1.1 showing the extent of the proposed works including the proposed converter station, Friston substation connection and cable routes which are described in more detail in Section 1.2.2.

The project area is located in Suffolk, between Saxmundham and Aldeburgh and runs adjacent to several smaller villages along its length e.g. Sternfield, Friston, Coldfair Green. The site is situated within lowland glacial terrain close to the coast. The ground levels rise from +0m AOD at the beach to around +15m AOD at Friston in the centre of the scheme, and up to approximately +25mAOD at the Converter Station at Saxmundham, although the overall terrain is gently undulating including crossing of river valleys such as the River Fromus at the western extent of the scheme.

All slopes are gentle with the lower slopes associated with glacial sand and gravel and/or Crag Group, and the higher topography associated with overlying Lowestoft Formation Diamicton (glacial till). The coastal plain has flat, low-lying topography associated with Alluvium and Tidal Flat Deposits at the eastern extents of the scheme, whilst the River Fromus and its narrow alluvial plain dissects the glacial deposits at the western end of the Scheme near Saxmundham.

1.2.2 Proposed works

The Sea Link project forms part of The Great Grid Upgrade and is an essential network reinforcement in East Anglia and the south-east to improve the aging and limited generation capacity of the existing network, which has limited capacity to support the growth in offshore wind, new interconnectors and nuclear power stations. The project will help reinforce the network:

- By connecting new planned generation, allowing power to be transferred;
- By connecting to the proposed Friston substation, Sea Link reinforces the Bramford-Sizewell radial circuits; and,
- By connecting into the Kent coast, it increases the amount of power that can be transported to and from the south-east, helping to meet domestic demand as well as imports and exports to Europe via interconnectors.

The overall project is split into three main elements alongside their associated other works, and this includes the Suffolk onshore scheme, the offshore scheme, and the Kent onshore scheme.

The proposed works summarised in this document consider the Suffolk onshore scheme only. Reference should be made to wider project documentation and reports for information for the Kent elements of the scheme. For Suffolk, information is presented on the following drawings (included in Appendix A), and are briefly described below:

- National Grid, Sea Link Order, Location Plan for Consultation, Sheet 1 of 1, Suffolk. Drawing reference: S42_S/OLP/SS/0001.
- National Grid, Sea Link Order, General Arrangement Plan Series for Consultation, Sheet 1 to 7, Suffolk. Drawing references: S42_S/IGA/PS-0001 to 0007.
- National Grid, Sea Link Order, General Arrangement Plan Series for Consultation, Sheet 1, Suffolk Colocation of Converter Stations. Drawing reference: S42_S/IGA/SS-0008

Design drawings showing these main proposed works in further detail are also summarised in Table 1.1 below with the geographic extent shown in Figure 1.1. It should be noted that there has been minor changes to options such as access roads since production of Figure 1.1 and these are captured in later sections of the report.

Further details on ancillary / enabling works such as access / haul road bell mouth arrangement details can be found with the Statutory Consultation drawing pack.

Table 1.1: Statutory Consultation – Design drawings (October 2023)

Drawing title	Drawing Number
The National Grid Electricity Transmission PLC (Sea Link) Order, Design Drawings for Consultation:	
Typical Saxmundham Converter Station Layout Plan (GIS), Sheet 1 of 1	S42_S/TDD/SS/0015
Typical Saxmundham Converter Station – Elevation Drawing, Sheet 1 and 2	S42_S/TDD/SS/0020

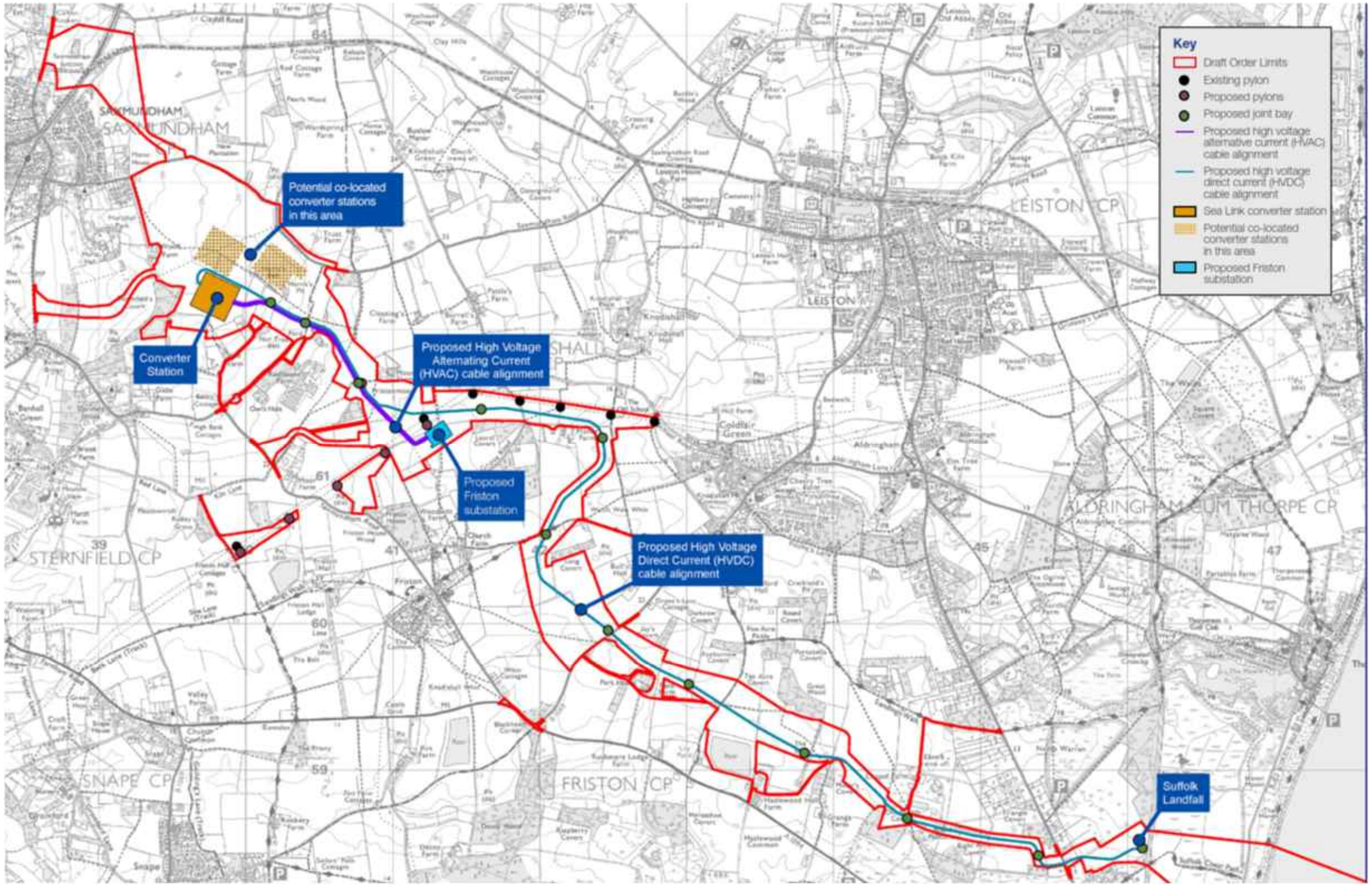
Drawing title	Drawing Number
Typical HVDC construction area for Sea Link plus ducts for up to two further projects	S42_S/TDD/SS/0018
Typical HVAC construction area for Sea Link plus ducts for up to two further projects	S42_S/TDD/SS/0013
Typical HVAC and HVDC combined construction area for Sea Link plus ducts for up to two further projects	S42_S/TDD/SS/0014
Typical HVAC direct buried cross section and construction area	S42_S/TDD/SS/0010
Typical 400kv HVAC joint bay arrangement	S42_S/TDD/SS/0011
Typical HVAC and HVDC combined construction area	S42_S/TDD/SS/0012
Indicative horizontal directional drill solution for Sea Link, (only Aldeburgh / plus ducts for up to two further projects Aldeburgh)	S42_M/TDD/SS/1042 and S42_M/TDD/SS/1041
Indicative layout of HDD construction compound for Sea Link, (only Aldeburgh / plus ducts for up to two further projects Aldeburgh)	S42_M/TDD/SS/1044 and S42_M/TDD/SS/1038

A high-level summary of the proposed works is presented below:

- A Converter Station (2GW, up to 26m tall plus external equipment such as lightning protection etc.) is proposed to the south-east of Saxmundham, with potential co-location options located in close proximity
- A High Voltage Alternating Current (HVAC) underground cable of c. 1.7km in length and High Voltage Direct Current (HVDC) underground cable of c. 10km in length, the alignment of which is presented on the drawings summarised above.
  - The HVAC cable route connects from the proposed Converter Station to Friston Substation
  - The HVDC cable route connects from the proposed Converter Station to the off-shore marine HVDC cable adjacent to the coastline, c. 900m on-shore.
  - A construction swathe associated with the cable construction, ranging between 40m to 112m wide during construction dependent on the options for future ducts / cables.
  - Selected areas of the cable route require Horizontal Directional Drilling, including the eastern end of the scheme for the HVDC off-shore connection.
- A permanent access route for construction of the scheme (crossing the River Fromus south-east of Saxmundham) joins to the Converter Station which is to include a bridge and approach embankments, as well as access routes for Friston Substation and access for construction along the length of the cable route.
- A series of construction compounds located along the length of the scheme in support of construction. It should be noted that the site boundary of the Draft Order is wider in some areas to allow for flexibility of the exact compound locations.
- Drainage infrastructure including permanent attenuation ponds associated with the proposed works
- Other ancillary works including pylon modification.

The project proposals for Sea Link have been developed as a standalone project, but include for opportunities to co-locate infrastructure for up to two other projects at the converter station location, along the cable corridors and at the landfall location.

Figure 1.1: Sea Link - project proposal – National Grid (2023)



Source: National Grid, The Great Grid Upgrade, Sea Link, Project overview document, October 2023

1.3 Geotechnical Category of the project

This project is classed as Geotechnical Category 2 in accordance with BS EN 1997-1 which is defined as conventional types of structure and foundation with no exceptional risk or difficult soil or loading conditions.

Designs for structures in Geotechnical Category 2 should include quantitative geotechnical data and analysis to ensure that the fundamental requirements are satisfied. Routine procedures for field and laboratory testing may be used.

1.4 Other relevant information

No other relevant information was available to evaluate at the time of writing this report.

2 Existing information

This section presents a high-level summary of the key existing information available at the site. Reference should be made to the Mott MacDonald Limited Geotechnical and Geo-environmental Preliminary Risk Assessment (SEAL-MMD-SEAL-ENG-REG-0056) for full details, as well as a series of drawings prepared in production with this report, detailed below and provided within Appendix A:

- Mott MacDonald Limited, National Grid (Sea Link) Order, Ground Investigation – Exploratory hole location plan including superficial geology, historical and current land-uses. Sheet 1 to 10, Drawing reference: SEAL-MMD-SEAL-ENG-DWG-0685
- Mott MacDonald Limited, National Grid (Sea Link) Order, Ground Investigation – Exploratory hole location plan including bedrock geology, historical and current land-uses. Sheet 1 of 1, Drawing reference: SEAL-MMD-SEAL-ENG-DWG-0685.

2.1 Topographic information

A detailed summary of the topographic information across the site is presented within the PRA, with a high-level summary included below. Section 1.2.1 also briefly discusses the topography in relation to the terrain observed:

- At the western extent of the scheme, ground levels rise from c. 9 – 14m AOD in the valley of the River Fromus gently to the Saxmundham Converter Station site, located at approximately 23 – 25m AOD.
- Ground levels are undulating within the glacial terrain across the length of the scheme with levels between c.13m AOD up to maximum levels of c. 25m AOD across the length of the cable routes, and are approximately 16 – 18m AOD at the Friston Substation connection in the centre of the site.
- The ground levels begin to gently decrease towards the coast north of Aldeburgh, down to c. 0m AOD at the coast.

2.2 Geological maps and memoirs

A summary of published geological information available from freely available sources (including the British Geological Survey) is presented below.

2.2.1 Published geology

The British Geological Survey (BGS) 1:50,000 Series Solid and Drift geological map, sheet 191 Saxmundham and BGS Memoir (Moorlock *et al*, 2000), as well as the BGS 1:10,000 map series across the site indicate the site to be predominantly underlain by the Lowestoft Till Formation which overlies the Crag Group. Minor areas of Alluvium can be expected along the River Fromus near Saxmundham. A series of plans presenting the BGS geology (bedrock, artificial and supervision) as well as the extents of proposed works is summarised within the drawings presented in Appendix A, to provide a generalised overview of the entire study area.

Descriptions of the stratum expected to be present at the site given by the BGS Lexicon of Named Rock Units are presented in Table 2.1. Tidal Flat Deposits and Marine Beach Deposits have been included in the table, however; these deposits are only expected within the vicinity of the offshore trenchless solution (i.e. HDD section) at landfall and are not indicated to be present within the onshore cable route corridor.

Table 2.1: BGS Lexicon of Named Rock Units

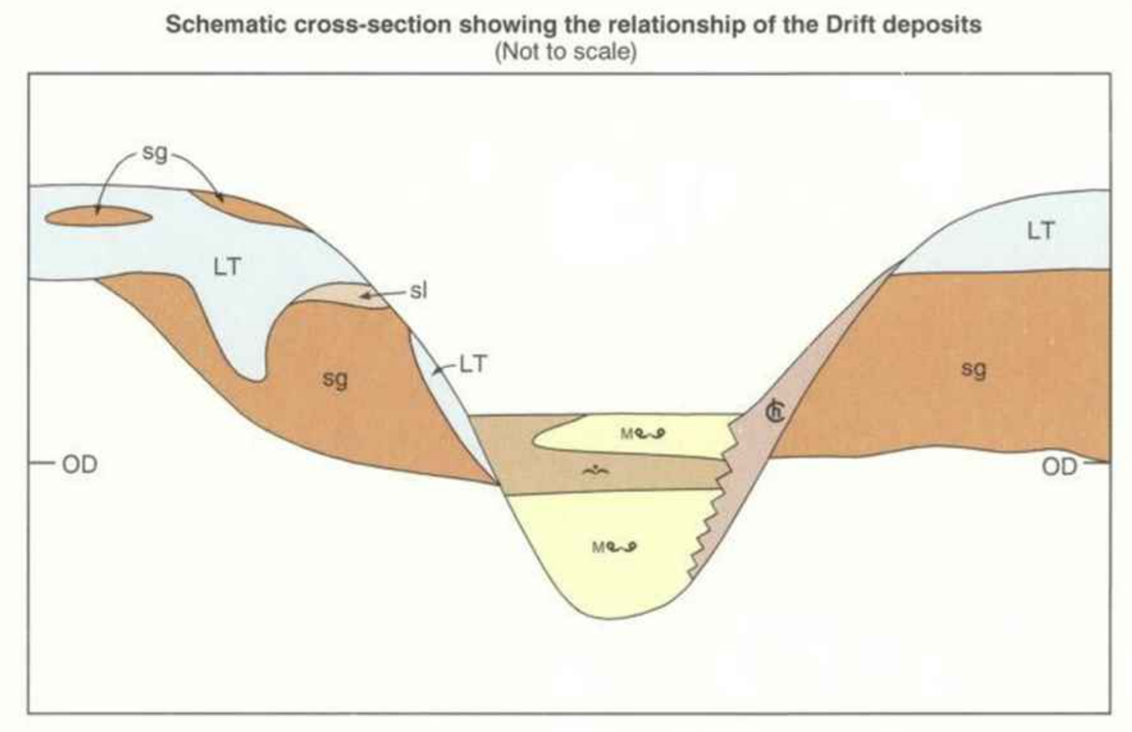
Stratum	Age Range	Parent Unit	Description
Tidal Flat Deposits (TFD)	Quaternary Period	Intertidal Deposits (ITD)	Normally consolidated soft silty clay, with layers of peat, sand and a basal gravel. A stronger, desiccated surface zone is sometimes present.
Marine Beach Deposits (MBD)	Holocene Epoch	N/A	Shingle, sand, silt and clay, may be bedded or chaotic. Beach deposits may be in the form of dunes, sheets or banks, in association with the marine environment
Alluvium (ALV)	Holocene Epoch	Fluvial Deposits (FLUV)	Clay, silt, sand and gravel. Unconsolidated detrital material deposited by a river, stream or other body of running water. Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel.
Lowestoft Formation (LOFT)	Anglian Stage	Albion Glaciogenic Group (ALBI)	An extensive sheet of chalky till, together with outwash sands and gravels, silts and clays. The till is characterised by its Chalk and flint content. The carbonate content of the till matrix is about 30%. Extremely variable thickness, up to 60m in buried valleys.
Chillesford Clay Member (CFC)	Pre-Pastonian/ Baventian Stage	Norwich Crag Formation (NCG)	Mainly unfossiliferous pale grey silty clay with rare sand laminae. Overlies the Chillesford Church Sand Member, locally oversteps onto Coralline Crag Formation and Red Crag Formation. 6m thick.
Chillesford Church Sand Member (CFB)	Antian/Bramertonian Stage	Norwich Crag Formation (NCG)	Well sorted fine to medium grained micaceous buff to pale brown, quartz sand. Overlies the Red Crag Formation. Up to 13m thick, local to parts of Suffolk.
Crag Group – Sand (CRAG)	Pliocene Epoch to Pleistocene Epoch	Great Britain Superficial Deposits Supergroup (GBG)	Sands, gravel, silts and clays. The sands are characteristically dark green from glauconitic but weathers bright orange with haematite 'iron pans'. The gravels in the lower part are almost entirely composed of flint. Those higher up include up to 10% of quartzite from the Midlands, igneous rocks from Wales, and chert from the Upper Greensand of south-east England. Up to 70m onshore.
Red Crag Formation (RCG)	Pliocene Epoch to Pleistocene Epoch	Crag Group (CRAG)	Similar description to CRAG as detailed above. Onshore commonly to 20m thick, but can be thicker locally in east Norfolk / Suffolk. Overlain by sands of the wider Crag Group which are less coarse-grained, better sorted, less shelly and paler in colour. Rests on the Coralline Crag Formation.
Coralline Crag Formation (CCG)	Pliocene Epoch to Gelasian Age	Crag Group (CRAG)	Carbonate rich skeletal sands. Thickness approximately 25m maximum onshore.
Thames Group (THAM)	Ypresian Age	N/A	Mainly silty clays and clays, some sandy or gravelly, with some silts, sands, gravels and calcareous mudstones. Up to 150m thick.

Although no Artificial Ground (Made Ground/ Worked Ground/ Landscaped Ground/ Disturbed Ground) is shown on the 1:50,000 scale mapping, there remains the potential to encounter localised pockets of Artificial Ground within the wider construction corridor or in proximity to the site potentially associated with historical land-use. This includes, for example, historic pits e.g. sand/gravel, brick or unspecified pits. Reference should be made to Section 2.5 and the PRA for further information and the drawings presented in Appendix A.

It is also likely that Made Ground will be present at discrete locations along within the construction swathe close to developed areas in the vicinity of buildings and infrastructure.

A conceptual relationship between the superficial deposits in vicinity of the Converter Station and wider glaciated terrain across the cable route is shown indicatively in Figure 2.1 to provide context to later parts of this section and report.

Figure 2.1: Sketch of superficial deposit relationship



Source: Annotated schematic interrelations of drift deposits from British Geological Survey, 1:50,000 Series, Sheet 191, Saxmundham. LT = Lowestoft Till, sg = sands and gravels, sl = silt, Ch = Head, M = Alluvium

2.3 Previous ground investigations on or adjacent to the site

2.3.1 Scottish Power Renewables

A ground investigation was undertaken by Structural Soils Limited on behalf of Scottish Power Renewables (SPR) as part of the EA1N Onshore project, summarised in the following report:

- Structural Soils Limited, Onshore Geotechnical and Geo-environmental Ground Investigation, Factual Report on Ground Investigation. SPR reference: EA1N-GRD-GEO-REP-SSL-000001, REV 21. SSL Report No: 735329-01(21).

The SPR intrusive ground investigation was undertaken by Structural Soils Ltd on behalf of their client East Anglia One North Ltd. Although for a different route alignment, the GI included exploratory holes in vicinity of the of the proposed substation connection and cable route. The locations of the BGS boreholes and SPR holes in relation to the proposed scheme are presented on the superficial geology plans included within Appendix A.

The investigation was between the coastline just north of Thorpeness and the proposed substation connection site for the construction of two new substations and associated infrastructure, junction improvements to the B1069 Snape Road and the A1094 Aldeburgh Road and onshore cable connections to an offshore connection point north of Thorpeness. The report was provided for review as part of Mott MacDonald’s scope by National Grid with agreement from SPR.

The overall scope of the investigation included:

- 18 no. cable percussion boreholes to a maximum depth of 30.00m bgl;
- 3 no. cable percussion boreholes with rotary follow-on to a maximum depth of 45.00m bgl;

- 341 no. machine dug trial pits to a maximum depth of 4.50m bgl;
- 6 no. window sample boreholes to a maximum depth of 5.00m bgl;
- 14 no. Cone Penetration Tests including 17 no. dissipation tests to a maximum depth of 9.29m bgl;
- 88 no. Thermal resistivity testing and 1 no. electrical resistivity survey;
- 263 no. Standard Penetration Tests in boreholes,
- 33 no. Soakaway infiltration tests in trial pits;
- A series of hand vane tests in trial pits;
- Post fieldwork monitoring of groundwater installations; and
- Geotechnical and geo-environmental laboratory testing.

Full details can be found in the Factual Report. Only exploratory holes relevant to the proposed areas of construction under consideration in this report have been selected for review in the following sections, including Section 3.3 and in support of the site ground models in this area of the site.

2.4 Encountered geology

The following sections summarise the existing boreholes identified on the BGS GeoIndex where considered relevant in vicinity of the site.

2.4.1.1 Converter Station

No existing boreholes, either historical BGS or Client provided are available within 1km of the proposed Saxmundham Converter Station site.

2.4.1.2 HVAC/ HVDC cable route corridor

Very few BGS exploratory holes are available along the alignment of the HVAC/ HVDC cable route, only 2 no. BHs (TM45NE10 and TM45SW5) have been identified using the BGS GeoIndex (a large number of holes are drilled for wells and therefore do not contain ground profile information and are of limited use).

There are no existing holes located between the coastline and Leiston Road, approximately 1.3km inland, however; geological mapping indicates Tidal Flat Deposits to be present within the majority of the offshore HDD section, with a small section having no superficial cover before the Lowestoft Formation is encountered. For the remainder of the route up to the convertor station, the following ground profile presented in Table 2.2 is anticipated based on the available (albeit limited) existing information. This should be treated with caution due to limited information available from the historical records, and due to the changes in ground level observed across the site.

Table 2.2: Anticipated Ground Profile from BGS BHs –HVDC cable route

Stratum	Depth to top m bgl	Thickness m
At Leiston Rd - TM45NE10		
Crag Group	0	19.1
Thames Group	19.1	>1.8
Approximately 1km west of Leiston Rd - TM45NW5		
Topsoil (TS)	0	0.6
Lowestoft Formation	0.6	13.11
Crag Group	13.71	>38.1

The Crag has been described in the TM45NE10 as dark yellowish orange fine to medium grained SAND, moderately well sorted with rare 10mm thick silty clay layers and shell fragments below 3.1m bgl to a depth of 4.5m overlying dark yellowish orange slightly glauconitic calcarenite becoming greenish grey with abundant glauconite.

In TM45NW5, the Crag Group is recorded as a sequence of orange sands with shells, sandy clay (locally with gravel), becoming green (interpreted as unweathered) with depth.

2.5 Mining, quarrying and geological hazard potential

2.5.1 BritPits

A search of the Brit Pits (British Pits) database containing information of currently active and closed surface and underground mineral workings maintained by the British Geological Survey by Groundsure indicates there are a number of features identified within or immediately adjacent to the construction swathe as detailed in the PRA report. Records in proximity to the site and the cable swathe are presented within the drawings in Appendix A.

The identified features are described as surface mineral workings. It may be termed Quarry, Sand Pit, Clay Pit or Opencast Coal Site.

It is noted that numerous further features have been identified outside of the construction swathe in the close vicinity, however, these are not considered a risk to the proposed construction and therefore have not been reviewed in detail. Full details of Brit Pits within 500m of the cable swathe are included in the Groundsure Insights report, reference should be made to the PRA for further details and the drawings within Appendix A.

2.5.2 Natural cavities

The Groundsure search of the Stantec UK Ltd national database of natural cavities indicates that there are no records of natural cavities within 500m of the construction swathe.

2.5.3 Surface ground workings

Groundsure have identified historical land uses from the Ordnance Survey mapping that involved ground excavation at the surface, which may or may not have been subsequently backfilled. A summary of the features identified within or immediately adjacent to the construction swathe is provided in Table 2.3. Locations of Surface Ground Workings within the construction swathe are presented on Drawings within Appendix A.

Table 2.3: Details of Surface Ground Workings identified within the Cable Swathe

Location	Groundsure ID	Land Use	Date range on mapping
HVDC cable route	AK	Gravel/ sand pit	1928 to 1947
	X	Brick works	1882
	F	Unspecified Pit	1947 to 1938
	AF	Unspecified pit	1903 to 1947
Convertor Station	None identified		
HVAC cable route	W	Unspecified pit	1882 to 1903
	D	Unspecified Pit/ old clay pit	1946 to 1953
	I	Unspecified hole/ pond	1946 to 1952
	G	Pond	1946 to 1952
Substation connection	B	Unspecified Pit	1946 to 1952

2.5.4 Underground workings

The Groundsure report has not identified any historical land uses from Ordnance Survey mapping to indicate the presence of underground workings within 1000m of the construction swathe.

2.5.5 Historical mineral planning areas

No historical mineral planning areas are recorded within 500m of the site from review of Groundsure information.

2.5.6 Mining

The Groundsure report indicates the following:

- There are no non-mining record or mining cavities identified within 1000m of the construction swathe.
- There are no records on site of the site being in a Johnson Poole and Bloomer (JPB) mining area and no records on site of coal mining.
- There are no records on site of gypsum or kaolin and ball clay extraction or tin mining on site.

2.5.7 Radon

The site is in an area where <1% of dwellings exceed the Radon Action Level – no radon protection measures are required as reported in the Groundsure report.

2.5.8 Geological Hazard Potential

The Groundsure report indicates the potential ground stability hazards along with hazard potential at the site sourced from the British Geological Survey - National Geoscience Information Service. A series of drawings are included within Appendix A presenting the level of hazard potential across the scheme, with information summarised briefly below:

- Collapsible deposits - Low
- Compressible ground - Low
- Landslides - Low
- Running Sand - Low
- Shrink / swell - Moderate
- Soluble rocks – Low

It should be noted that the above is based on freely available BGS data and is at a relatively coarse resolution, and it is possible that some of the risks may be greater associated with particular deposits at the site such as Alluvium along the River Fromus. These are discussed in more detail in the subsequent sections of the report as well as the geotechnical risk register within Section 10.

2.6 Hydrology and Hydrogeology

The below sections summarise the hydrology and hydrogeological information for the site, reference should be made to the PRA and Groundsure reports for further details.

2.6.1 Hydrology

2.6.1.1 Converter Station

No surface water features have been identified within the construction swathe in the vicinity of the convertor station.

2.6.1.2 Cable route corridor

- Three lakes are located to the north of the southern HVDC cable route option between approximate, the closest being around 60m from the construction swathe. The nearest and furthest are marked as swimming lakes on OS mapping, and the third is referenced as a pond in the Groundsure historical surface ground workings section.
- A surface water reservoir is located immediately south of the construction swathe at Hazelwood Hall Farm, with numerous smaller ponds located to the east of west of the reservoir one, the western most pond being within the access corridor from Aldeburgh Road.
- A drainage ditch is located approximately 30m north of the HVDC cable route which also extends from the southern end of the construction swathe and connects to the area of man-made drained coastal ground to the east.

2.6.1.3 Substation connection

- An un-named watercourse, likely a drain, is located around the east and south boundaries of the proposed temporary substation construction area within the northern extent of the construction swathe.
- An underground inland river is recorded to the immediate south-east of the proposed substation construction area, to the north of the proposed substation, which likely drains in a south-east direction within the Hundred River catchment.
- An un-named water course is located approximately 51m north of the construction swathe at the location of the substation connection.

2.6.2 Hydrogeology

2.6.2.1 Superficial aquifers

Details of superficial aquifers and their location within the construction swathe as obtained from the Groundsure report are presented in Table 2.4.

Table 2.4: Details of Superficial Aquifers within the Construction Swathe

Location	Aquifer Designation	Stratum
HVDC cable route	Secondary A	Lowestoft Formation – sand and gravel
	Secondary Undifferentiated	Lowestoft Formation – diamicton
Convertor Station	Secondary A	Lowestoft Formation – sand and gravel Alluvium (access route only)
	Secondary Undifferentiated	Lowestoft Formation – diamicton
HVAC cable route	Secondary A	Lowestoft Formation – sand and gravel
	Secondary B	Lowestoft Formation – silt and clay
	Secondary Undifferentiated	Lowestoft Formation – diamicton
Substation connection	Secondary A	Lowestoft Formation – sand and gravel

Location	Aquifer Designation	Stratum
	Secondary Undifferentiated	Lowestoft Formation – diamicton

The Environment Agency classification for the different types of aquifers is as follows:

- Undifferentiated ‐ Assigned where it is not possible to attribute either category A or B to a rock type. In general these layers have previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
- Secondary A ‐ Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formally classified as minor aquifers.
- Secondary B ‐ Predominantly lower permeability layers which may store/ yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

2.6.2.2 Bedrock aquifers

The Groundsure report indicates the whole of the construction swathe area is underlain by a Principal Aquifer (CRAG) described as geology of high intergranular and/ or fracture permeability, usually providing a high level of water storage and may support water supply/ river base flow on a strategic scale. Generally principal aquifers were previously major aquifers.

2.6.2.3 Groundwater vulnerability

The Groundsure report presents the groundwater vulnerability across the area local to the site based on an assessment of the vulnerability of groundwater to a pollutant discharge at ground level classified by the EA as follows:

- High Vulnerability – areas able to easily transmit pollution to groundwater. They are likely to be characterised by high leaching soil and the absence of low permeability superficial deposits.
- Medium Vulnerability – intermediate between high and low vulnerability
- Low Vulnerability – areas that provide the greatest protection from pollution. They are likely to be characterised by low leaching soils and/ or the presence of superficial deposits characterised by a low permeability.

The groundwater vulnerability within the construction swathe is summarised in Table 2.5.

Table 2.5: Groundwater Vulnerability within the Construction Swathe

Location	Groundwater Vulnerability	Stratum
HVDC cable route	Principal bedrock aquifer, medium vulnerability	CRAG
	Secondary superficial aquifer, high vulnerability	LOFT – sand and gravel LOFT – diamicton
Convertor Station	Secondary superficial aquifer, high vulnerability	LOFT – sand and gravel LOFT – diamicton
	Principal bedrock aquifer, low vulnerability	CRAG
HVAC cable route	Secondary superficial aquifer, high vulnerability	LOFT – sand and gravel LOFT – diamicton LOFT – silt and clay
	Secondary superficial aquifer, medium vulnerability	LOFT – diamicton

Location	Groundwater Vulnerability	Stratum
Substation connection	Secondary superficial aquifer, medium vulnerability	LOFT – diamicton LOFT – sand and gravel

2.6.2.4 Source Protection Zones (SPZs)

The Groundsure report presents the SPZs across the area local to the site. The alignment sections which fall within SPZs are summarised in Table 2.6, reference should be made to Appendix A for further details which includes a plan of SPZs across the site.

Table 2.6: Source Protection Zones within the Construction Swathe

Location	SPZ
HVDC cable route	Source Protection Zone 3 – Total Catchment
Convertor Station	Source Protection Zone 3 – Total Catchment
HVAC cable route	Source Protection Zone 3 – Total Catchment
Substation connection	Source Protection Zone 3 – Total Catchment

2.7 Flooding

2.7.1 River and coastal flooding

2.7.1.1 Converter Station

The convertor station is not located in an area of river and coastal flooding.

2.7.1.2 Cable route corridor

The cable route corridor is not located within an area of river and coastal flooding. The eastern extent of the HVDC cable route is located within an area where the risk of flooding is low, Flood Zone 2. Historical flood events have been recorded here and is also in an area that would benefit from flood defences.

The risk of flooding from rivers or sea categories are as follows:

- Very low - <1 in 1000 chance in any given year
- Low - <1 in 100 but greater than or equal to 1 in 1000 chance
- Medium - <1 in 30 but greater than or equal to 1 in 100 chance
- High - greater than or equal to 1 in 30 chance.

2.7.1.3 Substation connection

The substation connection is not located in an area of river and coastal flooding.

2.7.2 Surface water flooding

There are numerous small, isolated areas likely to flood as a result of extreme rainfall events identified within the construction swathe with the highest risk on site and within 50m of the site being 1 in 30 year return period, depth greater than 1.0m (maximum modelled flood depth).

2.7.3 Groundwater flooding

The majority of the construction swathe is at low to moderate risk of groundwater flooding. Some areas along the alignment are at negligible risk of groundwater flooding, which relate to areas where superficial deposits are absent or in areas where low permeability superficial deposits are present (LOFT – clay and silt).

2.8 Historical development and land use

2.8.1 Historical mapping

The following sections have been summarised from reviewing historical mapping provided by Groundsure. The information is summarised for the Converter Station, cable route corridor and substation connection in the subsequent sections and presented in the Groundsure report.

2.8.1.1 Converter station

The site and surrounding area have remained largely undeveloped over time, comprising agricultural land with some small sand pits / unspecified ground workings. In proximity. Reference should be made to the PRA report and Groundsure information for full details.

2.8.1.2 Substation connection

The site has remained agricultural land since the earliest maps, with surrounding land comprising roads, farm houses and woodland. Historical workings are recorded in the surrounding area. Reference should be made to the PRA report and Groundsure information for full details.

2.8.1.3 Cable route corridor

The land-use across the proposed cable route corridor has largely remained as agricultural land, with several road crossings and reservoirs adjacent to the corridor. In the surrounding area, the land comprises roads, farm houses, woodland and villages with recreational areas, and a golf course west of Aldeburgh. Reference should be made to the PRA report and Groundsure information for full details.

2.8.1.4 Summary

The available mapping/aerial photography indicates that the majority of the construction swathe comprises undeveloped agricultural land.

Numerous unspecified pits / sand pits / clay pits have been identified both on-site and off-site, which could represent potential sources of contamination due to unknown infill materials. Additionally, residential development, road development, and the historical railway line and nearby nuclear power station could also represent potential sources of contamination.

Based on the identified land uses and the Department of Environment Industry Profiles contaminants of concern are likely to include, but are not limited to, metals and metal compounds, hydrocarbons (polycyclic aromatic hydrocarbons, total petroleum hydrocarbons), asbestos, polychlorinated biphenyls, fuels, oils, pesticides, insecticides, herbicides and other agricultural chemicals. These are likely to be localised, if present, and do not represent widespread contamination.

Reference should be made to the Generic Quantitative Risk Assessment which is reported separately for further information (see Section 7).

2.9 Site sensitivity and environmental designations

2.9.1 Waste and landfill sites

There are no historical waste sites within 250m of the construction swathe.

There are a series of waste exemptions related to agricultural waste, reference should be made to the PRA and Groundsure report for further information.

2.9.2 Pollution incidents

There is one recorded pollution incidents within 500m of the construction swathe. These are associated with Atmospheric pollutants (smoke), recorded as a Category 3 – Minor Impact to Land and Air. For further details reference should be made to the PRA and Groundsure report.

2.9.3 Hazardous substances

2.9.3.1 Control of Major Accident Hazards (COMAH)

There are no Control of Major Accident Hazards records within 500m of the construction swathe.

2.9.3.2 Hazardous substance storage / usage

There are no records of hazardous substance storage/usage within 500m of the construction swathe.

2.9.3.3 Radioactive substance authorisations

There are no radioactive substance authorisations within 500m of the construction swathe

2.9.3.4 List 2 Dangerous Substances

There is one record of discharges of substances identified on the List II of European Directive E 2006/11/EC within 500m of the construction swathe, as detailed in Table 2.7. For further details reference should be made to the PRA and Groundsure report.

Table 2.7: List 2 Dangerous Substances

ID	Distance / Direction	Name	Status	Receiving Water	Authorised Substances
M	83m south	Aldeburgh STW	Not Active	-	-

2.9.4 Current industrial land uses

2.9.4.1 Recent industrial land uses

There are several recent industrial land uses recorded within 250m of the construction swathe,

For full details, reference should be made to the PRA and Groundsure report.

2.9.4.2 Current / recent petrol stations

There are no petrol stations recorded within 500m of the construction swathe.

2.9.5 Discharge consents

There are several licensed discharges to controlled waters within 500m of the construction swathe. For further details reference should be made to the PRA and Groundsure report.

2.9.6 Water abstractions

2.9.6.1 Groundwater

There are several recorded groundwater abstractions within 500m of the construction swathe, one of which is within 50m, as shown in Table 2.8. Full details can be found in the PRA / Groundsure report.

Table 2.8: Groundwater Abstractions

ID	Distance / Direction	Name	Details	Date	Status
4	40m south	Executors of JR Somerville (Deceased)	General Farming and Domestic	1966 – 1978	Historical

2.9.6.2 Surface water

There are recorded surface water abstractions within 500m of the construction swathe, none of which are on-site. Full details can be found in the Groundsure report.

2.9.6.3 Potable abstractions

There are recorded potable abstractions within 500m of the construction swathe, none of which are on-site. Full details can be found in the Groundsure report.

2.9.7 Nitrate vulnerable zones

Two nitrate Vulnerable Zones are recorded within the construction swathe as follows:

- Fromus – Surface Water
- Sandlings and Chelmsford – Groundwater

2.9.8 Environmental designations

The vast majority of the construction swathe is without environmental designations. Areas where environmental designation apply are summarised in the PRA and Groundsure report, with a high-level summary included below:

- An area of Ancient and Semi-Natural Woodland is located immediately adjacent to the construction swathe at the end of the HVDC cable route.
- An area of Ancient Replanted Woodland, Grove Wood, is located immediately adjacent to the construction swathe at the end of the HVAC cable route
- A Site of Special Scientific Interest (SSSI) is located immediately adjacent to the eastern end of the southern HVDC cable route option – covering areas north of Aldeburgh

The whole construction swathe is within an SSSI Impact Risk Zone.

The coastal end of the HVDC cable route options lie within an Area of Outstanding Natural Beauty – Suffolk Coast & Heaths.

A Scheduled Ancient Monument, two bowl barrows on Aldringham Green, is located within a small rectangular area excluded from the construction swathe but surrounded by the construction swathe.

Reference should be made to the PRA and Groundsure report for further details.

2.10 Unexploded ordnance (UXO)

Detailed UXO Risk Assessments have been undertaken for the site by SafeLane Global, summarised in the following reports:

- Safelane Global, Detailed Unexploded Ordnance Risk Assessment, Friston 1, Report reference: 9758-1 RA, June 2023.
- Safelane Global, Detailed Unexploded Ordnance Risk Assessment, Sea Link Outline, Suffolk - Revision, Report reference: 9758-2 RA, June 2023

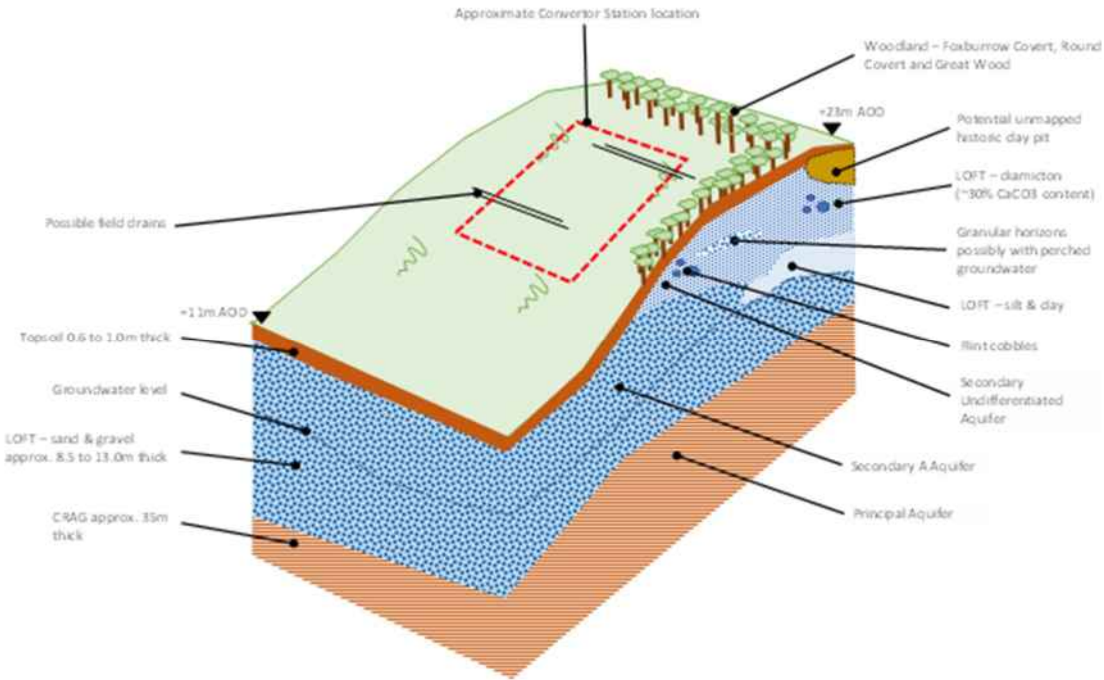
The reports indicate that the UXO risk across the site varies between medium to high. Reference should be made to the reports for their recommended mitigation measures.

2.11 Preliminary Ground Models

A series of conceptual geotechnical ground and groundwater models for the convertor station and substation connection are presented in the following sections and have been developed by considering the available geological mapping, site topography and existing (historical) ground investigation data. This information has been taken from the Geotechnical and Geo-environmental Preliminary Risk Assessment (SEAL-MMD-SEAL-ENG-REG-0056).

2.11.1 Converter station

Figure 2.2: Preliminary ground model – Converter Station



- The site slopes down from approximately +23m AOD in the north-east to approximately +11m in the south-west in the area of proposed construction. Therefore cut/ fill will be required to construct the convertor station platform.
- There are no existing boreholes located on the proposed site; therefore, the anticipated ground profile has been based on BGS boreholes located within 1.5km, of the site along with geological mapping.
- A thickness of cohesive till (Lowestoft Formation – diamicton) is anticipated on the higher ground to the north, possibly with a thin band of Lowestoft Formation – silt and clay. Below this the granular till (Lowestoft Formation – sand and gravel) is anticipated to range in

thickness between approximately 8.5 to 13m overlying the Crag Formation. The relatively high Chalk content can lead to re-cementation on compaction and it can also lead to rapid drying of the fill between excavation and deposition.
- Made Ground is not anticipated to be present based on the current and historical land use, however, it is possible that an unmapped historical clay pit may be located on or across part of the site.
- Groundwater is not anticipated within the depth of excavation; however, it is possible that localised groundwater seepage from granular bands within the Lowestoft Formation- diamicton maybe encountered. Cobbles of flint are likely to be encountered within the diamicton.
- There is potential for areas of archaeological interest to be present, it is also likely that field drains will be encountered in some excavations.

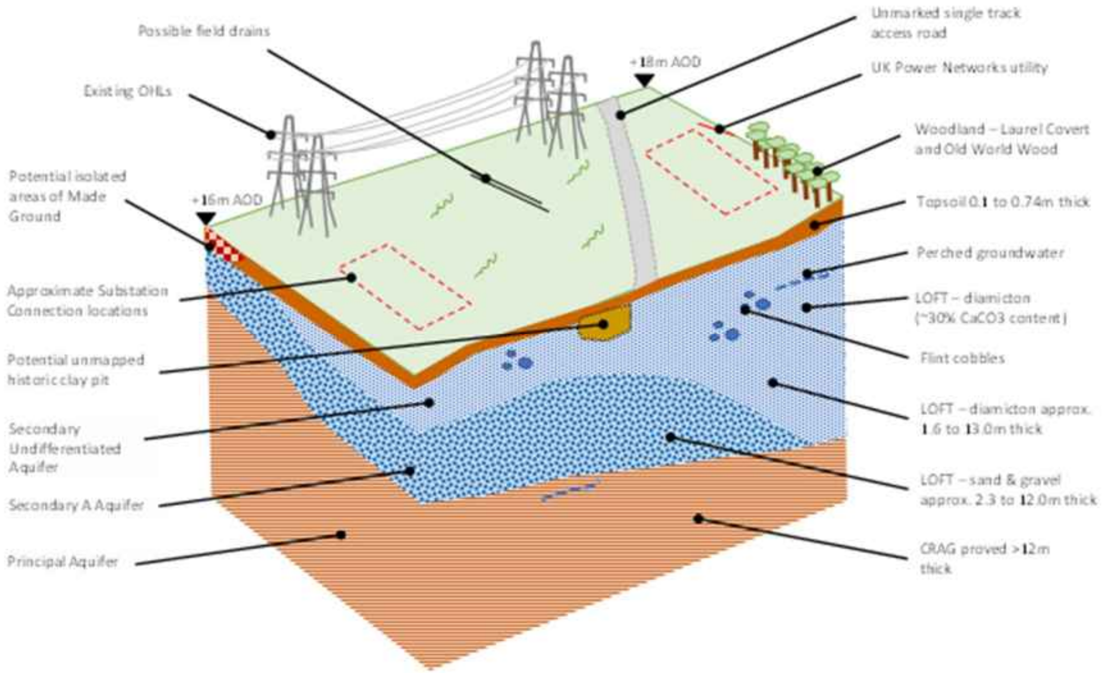
2.11.2 Cable route corridor (HVAC / HVDC)

- Very few existing historical holes are available along the alignment, therefore the anticipated ground conditions are based on a review of the limited holes available and geological mapping.
- The start of the alignment at the eastern end is likely to lie directly onto the Crag Group.
- The remainder of the alignment is anticipated to be underlain by Lowestoft Formation - sand and gravel and Lowestoft Formation- diamicton (which overlies the granular sand and gravel deposits, with a total maximum thickness up to c. 19m. Localised areas may also encounter the Lowestoft Formation – silt and clay. The Crag Group is anticipated to be encountered at depths of between around 13 and 19m bgl in these areas.
- Groundwater is not anticipated to be encountered in the excavations with the exception of those located at the coastal end of the alignment.
- Localised Made Ground may be encountered particularly in more built-up areas or in the vicinity of existing infrastructure. There is potential for areas of archaeological interest to be present, it is also likely that field drains will be encountered in some excavations within agricultural fields.

2.11.3 Substation connection

Information to develop the preliminary ground model for the substation connection is based on the nearby available BGS historical engineering logs, as well as the historical 2021 GI undertaken by Structural Soils for Scottish Power Renewables (see Section 2.3).

Figure 2.3: Preliminary ground model – Substation connection



- The site is generally flat at an elevation of approximately +18m AOD in the east to +16m AOD in the west. There are two National Grid overhead lines immediately to the north of the site and a UK Power Networks electricity cable to the east of the site.
- There are numerous BGS holes within 1.5km of the site and fifteen boreholes carried out by SPR on or in the immediate vicinity of the site.
- The site is underlain by a thin layer of Topsoil overlying Lowestoft Formation‐ diamicton which thins out to the north-east. The Lowestoft Formation (diamicton) varies in thickness from approximately 1.6 to 13m, being deepest below the eastern extent of the site and not present in the two boreholes on the western extent of the site.
- The Lowestoft Formation (diamicton) overlies the Lowestoft Formation (sand and gravel) across the majority of the site except in the boreholes located at the eastern extent of the site where the diamicton directly overlies the Crag Group
- The depth to the top of the Crag Group varies across the site between approximately 2.9m in the north-west to 13.4m in the east.
- Made Ground is generally not anticipated; however, one SPR borehole located to the north of the proposed substation connection encountered 0.58m of Made Ground.
- Groundwater was encountered in a small number of the SPR boreholes at depths ranging between 5.6 and 14m bgl.
- There is potential for areas of archaeological interest to be present. It is also likely that field drains will be encountered in some excavations.

3 Field and laboratory studies

3.1 Walkover survey

A walkover was attended by representatives of Mott MacDonald Limited prior to the intrusive ground investigation in 2023, to agree access routes and confirmation of exploratory hole locations and ancillary works. No distinct additional observations were captured during this walkover, with the walkover focussed on the proposed exploratory hole locations, access routes and particular constraints associated with undertaking the proposed works.

3.2 Geomorphological and geological mapping

No geomorphological or geological mapping has been undertaken for the site.

3.3 Summary of historical ground investigations

As presented in Section 2.3, a previous ground investigation was undertaken by Structural Soils Limited on behalf of Scottish Power Renewables (SPR) as part of the EA1N Onshore project.

At the time of writing, this information has not been warranted for use for this project, with information assessed to inform ground conditions in vicinity of the substation connection and cable route north of Friston only.

An exploratory hole location plan of boreholes from this GI which have been considered in this report are presented in Appendix A and shown in a sketch in Figure 4.1, as well as the overall scope covered as part of the GI.

Full details can be found in the Factual Report. Only exploratory holes relevant to the proposed areas of construction under consideration in this report have been selected for review in the following sections.

3.4 Summary of project specific ground investigation

In 2023 a preliminary de-risking ground investigation was undertaken, the aim of which was to obtain sufficient information on the ground conditions for the main contractors to price the construction contract without the necessity to include a significant risk contingency sum for unknown ground conditions. This was undertaken with the recognition that a further phase of GI will be carried out later in the project by the appoint construction contractor.

This ground investigation was undertaken between September and October 2023 by Structural Soils Limited, reported in the following report:

- Structural Soils Limited, Suffolk Onshore Cable Link, Factual Report on Preliminary Ground Investigation, Report No: 563835-01 (03), April 2024

The ground investigation was scoped and supervised by Mott MacDonald Limited, including wider support and agreement of exploratory hole locations with AECOM, who are the Environmental Consultant supporting the project in relation to environmental constraints such as ecology and archaeology / heritage.

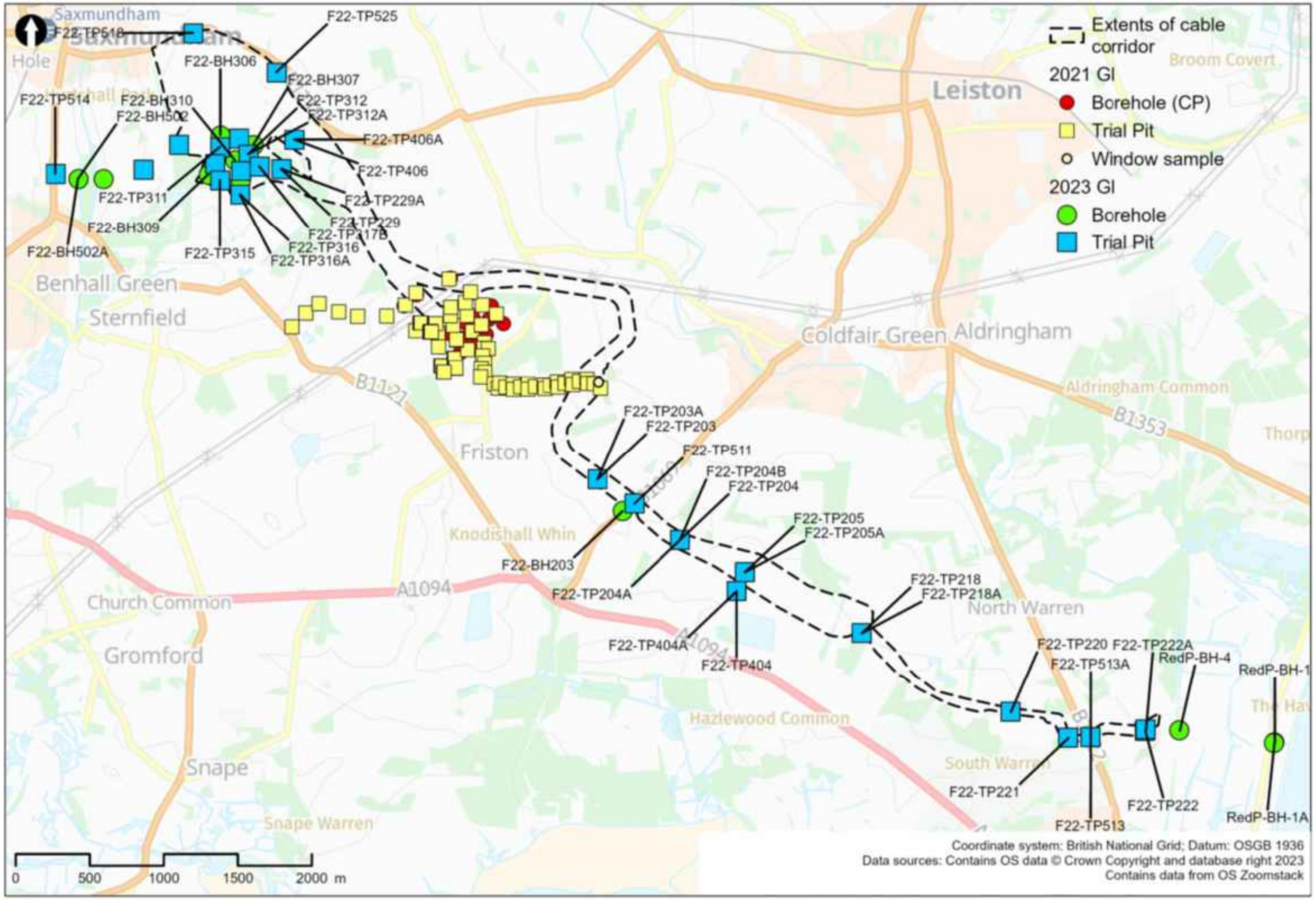
Mott MacDonald Limited scheduled the laboratory geotechnical and geo-environmental testing. It should be noted that boreholes were included as part of this scope to inform Red Penguin's offshore design, Red Penguin were consulted to review testing requirements within these boreholes.

The location of the exploratory holes are presented in drawings within Appendix A as well as Figure 4.1. This included:

- 12 No. Cable percussive boreholes to depths of approximately 30m bgl;
- 26 No. Machine dug trial pits undertaken to maximum depths of approximately 4m bgl;
- Installations for groundwater monitoring, including installation of automatic data loggers (divers) to monitor long-term groundwater levels;
- Geotechnical laboratory testing on soils
- In-situ testing including:
  - Standard Penetration Tests (SPTs)
  - Downhole permeability testing to assess soil permeability
  - Soakaway testing in accordance with BRE 365 within trial pits
  - Dynamic Cone Penetrometer testing to inform pavement design
  - Thermal resistivity testing to determine the properties of the soil for cable design; and,
  - Soil resistivity using the Wenner array to determine soil conductivity for earthing design
- Chemical laboratory testing on soils and groundwater
- Establishing ground locations of exploratory holes;
- Factual reporting to BS EN 1997-2-2007 incorporating corrigendum June 2010;
- Groundwater monitoring for a period of approximately three months following the completion of fieldwork, followed by twelve months of monitoring with automatic data divers in selected exploratory holes. Monitoring of data divers is in progress at the time of writing.

In addition, at the time of undertaking the ground investigation, certain areas of the site were not accessible during the fieldworks and therefore no GI could be carried out. This includes for example the Friston Substation and its connection to / from the proposed buried cables. Other areas include but are not limited to selected site compounds, due to subsequent changes in design proposals and/or land access constraints.

Figure 3.1: Exploratory hole locations – 2021 (SPR) and 2023 GI



4 Ground Summary

This section of the report discusses the deposits likely to be encountered on site. The assessment is based on the geological unit allocations at the time of ground investigation but may be subject to review and amendment during future stages of design and completion of additional site investigation.

4.1 Ground models from site-specific investigation

A series of ground models have been prepared summarising the ground conditions across the site footprint. These have been separated due to their spatial relationship with the anticipated geology and the proposed works, with a plan showing these in Appendix B.

It should be noted that some of the ground models including the substation connection and its access road is based on engineering log information from the 2021 GI undertaken for SPR by Structural Soils Limited.

The site is located across lowland glacial terrain, with a high-level summary of anticipated ground conditions below:

- The ground levels rise from +0m AOD at the beach to around +15m AOD at Friston in the centre of the scheme, and up to approximately +25mAOD at the Converter Station at Saxmundham, although the overall terrain is gently undulating including crossing of river valleys such as the River Fromus at the western extent of the scheme.
- All slopes are gentle with the lower slopes associated with glacial sand and gravel and/or Crag Group, and the higher topography associated with overlying Lowestoft Formation Diamicton (glacial till).
- The coastal plain has flat, low-lying topography associated with Tidal Flat Deposits at the eastern extents of the scheme, whilst the River Fromus and its narrow alluvial plain dissects the glacial deposits at the western end of the Scheme near Saxmundham.

A brief summary of the ground conditions encountered across the site is presented in the below table. A series of site ground models applicable for certain areas of the site are presented within Appendix B, and inform development of relevant design ground models in later sections of this report. To explain the relationship of some of the deposits listed below, reference should be made to Section 4.2 where a sketch geological section is presented.

Table 4.1: High level ground condition summary

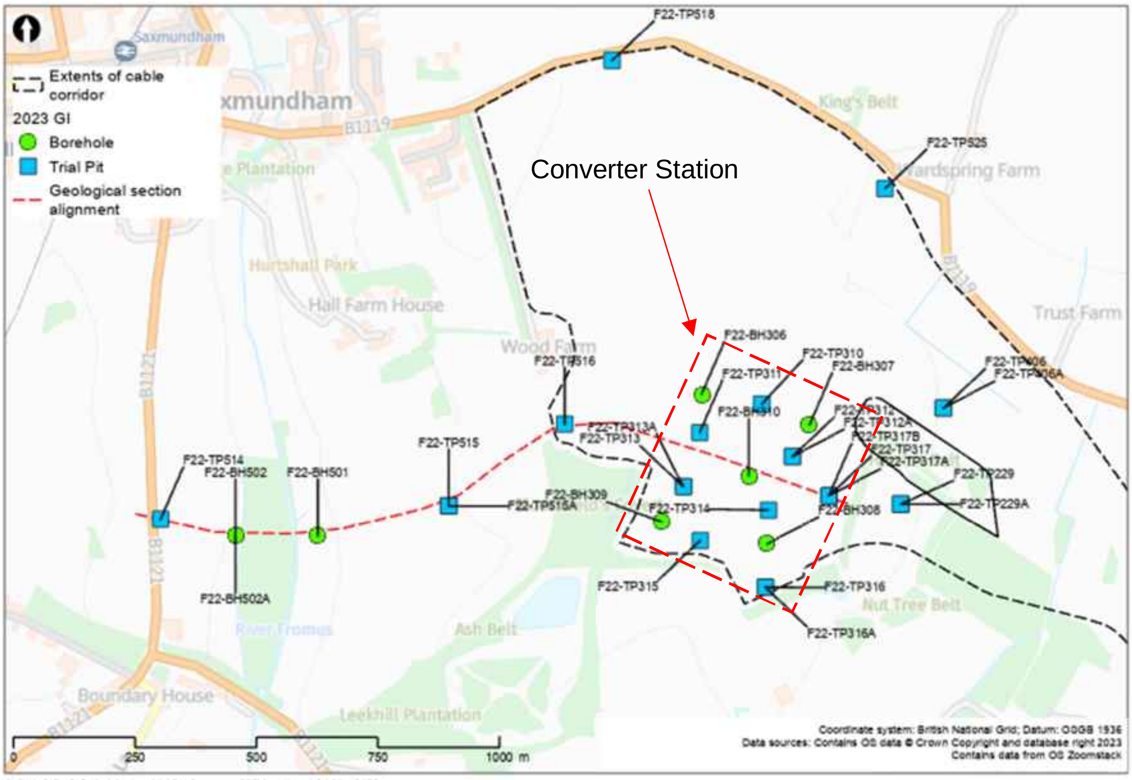
Strata	Description	Remarks
Topsoil	Ranges between soft to firm or stiff slightly gravelly or sandy CLAY / SILT to slightly gravelly or silty SAND with rare to frequent rootlets, occasionally noted as organic	Encountered at surface in most locations due to exploratory holes within agricultural fields / rural settings. Generally overlain by crops within agricultural fields.
Made Ground	Soft black slightly gravelly sandy CLAY with occasional glass fragments, hydrocarbon odour / staining In vicinity of Red Penguin – sandy angular to rounded GRAVEL	Encountered locally only, generally reworked from underlying natural deposits

Strata		Description	Remarks
Alluvium		Very loose to loose slightly clayey slightly gravelly SAND to soft sandy clayey SILT / sandy silty CLAY with occasional shell fragments	Encountered in vicinity of River Fromus only
Lowestoft Formation	Diamicton	Soft to firm, generally becoming very stiff yellowish brown to bluish / dark grey slightly to sandy slightly to gravelly CLAY with low cobble content. Pockets / lenses of fine to coarse / clayey or silty sand or silt noted generally towards its top. Rootlets present throughout.	Forms the elevated plateau at Saxmundham and areas of greater elevation along cable route. Occasional bands of sand and gravel noted throughout (see below). Locally sandier in vicinity of Snape Road
	Sand and Gravel	Medium dense to very dense yellow to orangish brown slightly gravelly clayey or silty fine to coarse SAND, locally varying to sandy GRAVEL. Occasional low cobble content of flint Locally encountered as soft orangish brown slightly gravelly sandy SILT to very stiff slightly gravelly slightly sandy silty CLAY	Encountered as beds within Diamicton, as well as a more major unit underlying it and within areas of lower elevation Locally encountered as silt / clay in vicinity of Snape Road – potential to be associated with Lowestoft Formation – Silt and Clay
	Possible Silt and Clay	Soft to firm, locally to very stiff orange brown slightly gravelly sandy SILT. Locally noted as organic or containing shell fragments.	Interpreted from SPR boreholes only
Tidal Flat Deposits		Very soft to soft CLAY to spongy fibrous black PEAT with a strong hydrocarbon odour and staining	Encountered in Red Penguin area only
Marine Beach Deposits		Medium dense slightly sandy rounded fine to coarse GRAVEL	Encountered in Red Penguin area only
Crag Group		(locally medium dense) dense to very dense orangish brown to dark grey slightly to gravelly clayey or silty SAND with rare to occasional shell fragments, occasional flasers of clay / silt. Locally encountered as very stiff thinly laminated sandy silty CLAY, SANDSTONE with iron staining (recovered as gravel/cobble sized fragments), or sandy GRAVEL	Clay bands could potentially be associated with the Chillesford Church Sand Member in vicinity of Aldeburgh.
Coralline Crag Formation		Medium to very dense orange / orangish brown becoming light or dark grey slightly clayey gravelly SAND with occasional to frequent shell fragments. Gravel is fine to coarse cemented sand and shells. Locally encountered as very stiff very sandy SILT.	
London Clay Formation		Stiff to very stiff bluish grey slightly sandy silt CLAY with occasional shell fragments	Encountered at River Fromus and Red Penguin area only due to borehole depth

4.2 Ground model visualisation

A geological section has been prepared through the western end of the project, from the access road south of Saxmundham to the Converter Station site. The section alignment is presented in Figure 4.1.

Figure 4.1: Sketch geological section alignment at Converter Station

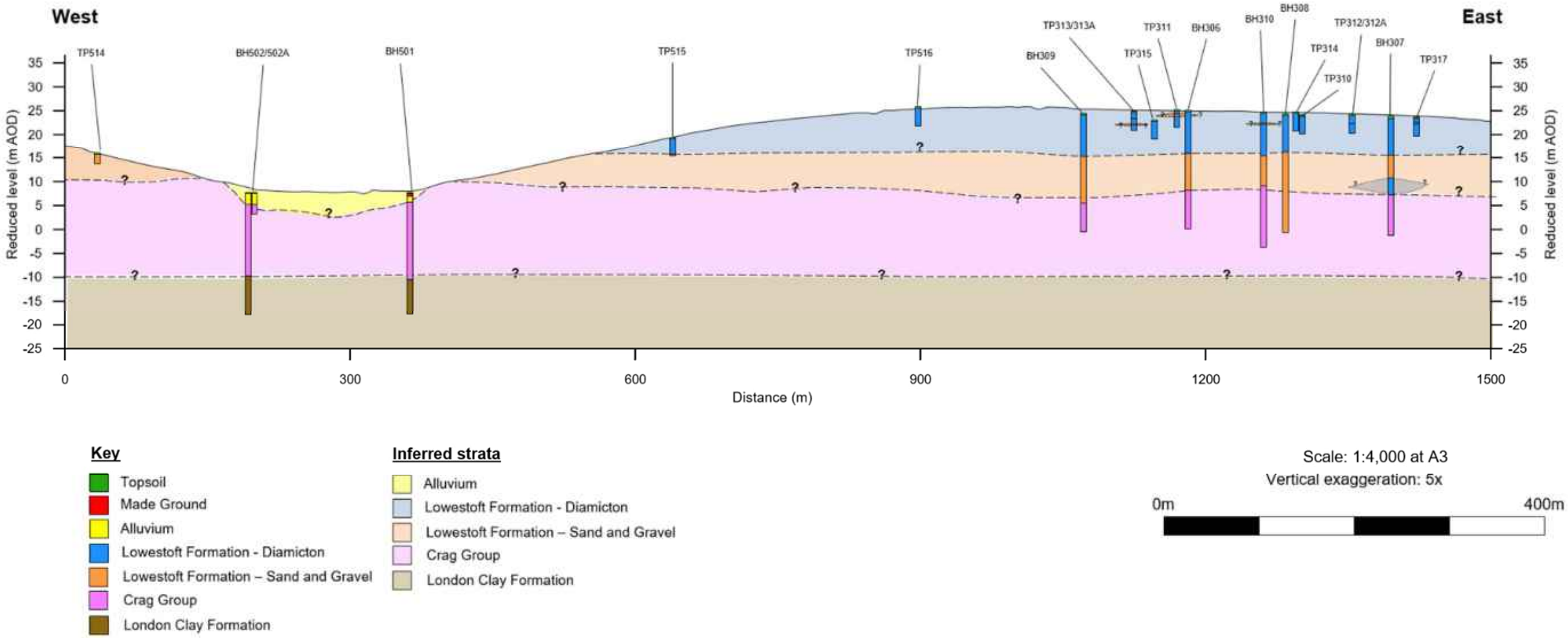


Due to the variable nature of ground conditions along the cable route, other areas have not been presented via geological sections. In addition, for the eastern end of the project north of Aldeburgh, exploratory holes will be reviewed in more detail by Red Penguin to inform their HDD alignments (RedP-BH01, BH01A and BH4).

The data has been extrapolated based on the geological relationships and distributions indicated on the BGS mapping, and is shown to broadly correlate with the expected geology. As discussed above and within Section 6, distinguishing between the Lowestoft Formation – Sand and Gravel and the underlying Crag Group can be difficult due to its weathering and potential for reworking during deposition, therefore the inferred strata boundaries should be treated with caution. Although present at surface across the majority of locations, Topsoil has not been separated on the section but is known to be present.

Limited topographic information is available along the section alignment, therefore ground levels have been estimated based on freely available open-source LIDAR information available at 1m resolution on the Department for Environment, Food & Rural Affairs (DEFRA) Data Services Platform (2024). Due to limited information in the valley of the River Fromus, it is not possible to fully understand the inter-relationship of the Alluvium deposits and their potential maximum thickness, including any potential presence of organic clays or peats. Only an idealised, simplified geological section has been presented based on the current available information.

Figure 4.2: Sketch geological cross section - Saxmundham



5 Ground conditions and material properties

This section of the report discusses the global geotechnical properties of the materials likely to be encountered on site. The assessment is based on the geological unit allocations identified at the time of the GI, but this may be subject to review and amendment during further stages of design and following the completion of any additional GI that may be undertaken. Information presented is shown with respect to metres below ground level (m bgl) and/or metres above ordnance datum (m AOD) where relevant.

5.1 Topsoil

Topsoil was encountered in the vast majority of locations at surface, and generally ranged in thickness between 0.15 – 0.55m.

The material description of Topsoil generally varied dependent on the underlying geology. This ranged from a soft to firm slightly sandy CLAY/ SILT to a silty/clayey SAND with rootlets, and was locally described as organic.

Topsoil has not been assessed in detail from a geotechnical perspective as it is anticipated to be stripped during construction. However, it is recommended that other assessments are taken to determine its re-use potential, should any excess material be present on site after reinstatement at the next design stage. See Section 9 for further information.

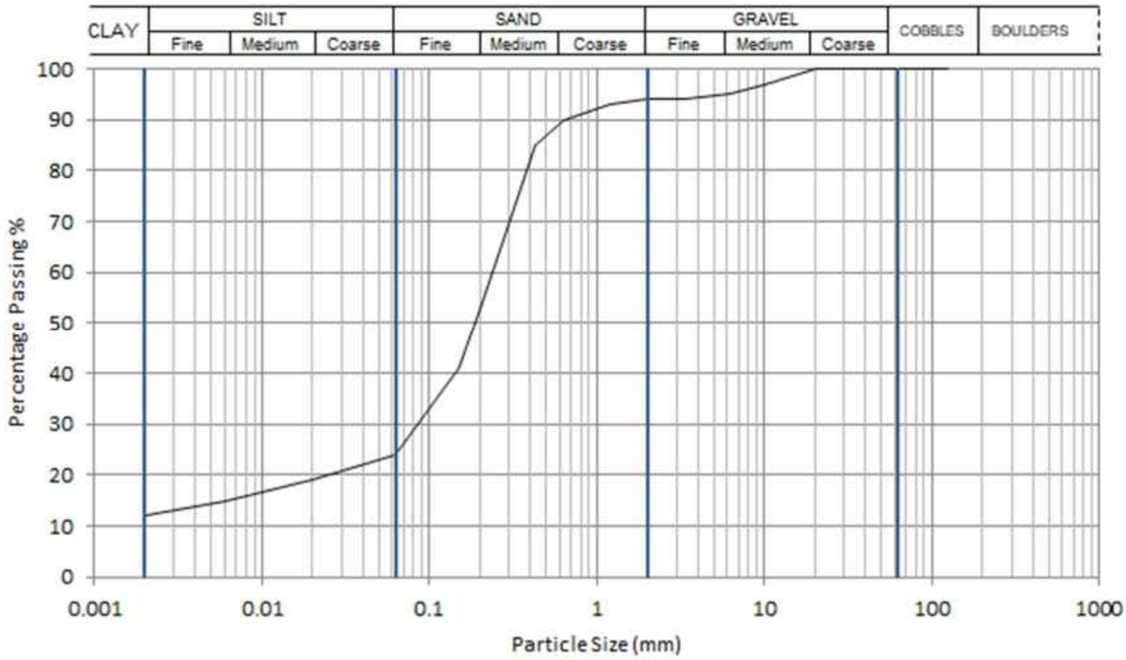
Limited testing was undertaken on Topsoil, summarised within Table 5.1. A total of eight organic matter content tests were undertaken, indicating ranges of organic matter content between 0.70 – 3.1%. The results indicate the material varies has an organic content lower than the defined limit for a ‘low organic content’ in accordance with BS 5930:2015+A1:2020.

Table 5.1: Topsoil – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Organic matter content	8	0.70	3.1	1.7	1.7

One particle size distribution test was undertaken in topsoil presented in Figure 6.1, described as a slightly gravelly clayey / silty sand and correlates with the engineering log description at the sampling location.

Figure 5.1: Topsoil – Particle size distribution testing



5.2 Made Ground

Limited Made Ground was encountered across the site footprint.

Along the cable route, localised Made Ground was recorded where fragments of brick / pottery were noted at surface with the engineering description of the material similar to that of the topsoil presented in Section 6.1. Examples of the variability of this material are presented below:

- Made Ground was encountered in BH501 as a soft black slightly gravelly slightly to sandy CLAY with occasional glass fragments. It is possible that this is reworked from the underlying Alluvium deposits. This was encountered at 0.15m bgl and was recorded as 0.75m in thickness.
- Made Ground was encountered in RedP-BH-1 and 1A as a brown to black sandy angular to rounded GRAVEL with fragments of brick, glass, ceramic, concrete and shell fragments. It was recorded up to 1.5 - >2.5m in thickness (thickness not proven where >2.5m in RedP-BH-1), and may be reworked from the underlying Marine Beach Deposits.
- Locally this material was recorded as a gravelly fine to coarse SAND of 0.45m thickness, with gravel formed of flint, limestone, sandstone, brick fragments, with occasional whole bricks. Archaeological evidence including flint and suspected arrow heads were recorded in TP222A.

5.2.1 Soil classification testing

Soil classification testing undertaken in the Made Ground is summarised below. This is described with respect to cohesive and granular elements where necessary.

Table 5.2: Made Ground (Cohesive) – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content (%)	2	55.6	67.2	61.4	61.4
Plastic limit (%)	2	36	40	38	38

Parameter	No. of tests	Minimum	Maximum	Average	Median
Liquid limit	2	67	80	73.5	73.5
Plasticity Index (%)*	2	31	40	35.5	35.5
Consistency Index (Ic)	2	0.00	0.61	0.30	0.30
Organic matter content (%)	1		8.4		

Cohesive Made Ground was encountered at BH501, along the access route crossing the River Fromus. One organic matter content test was undertaken in the Cohesive Made Ground, recording an organic content of 8.4%. This would suggest a medium organic content in accordance with BS 5930:2015+A1:2020.

Two moisture content tests indicated moisture contents between 55.6 – 67.2%, and the same samples recorded plasticity indices of 31 and 40. Elevated moisture contents are suggestive of presence of organic matter, which correlates with the test undertaken suggesting a medium organic content.

These two plasticity tests suggest the material is a high to very high plasticity silt based on the A-line plot.

Consistency index from the same two samples has been calculated based on the following equation

$$I_C = \frac{LL - w}{LL - PL}$$

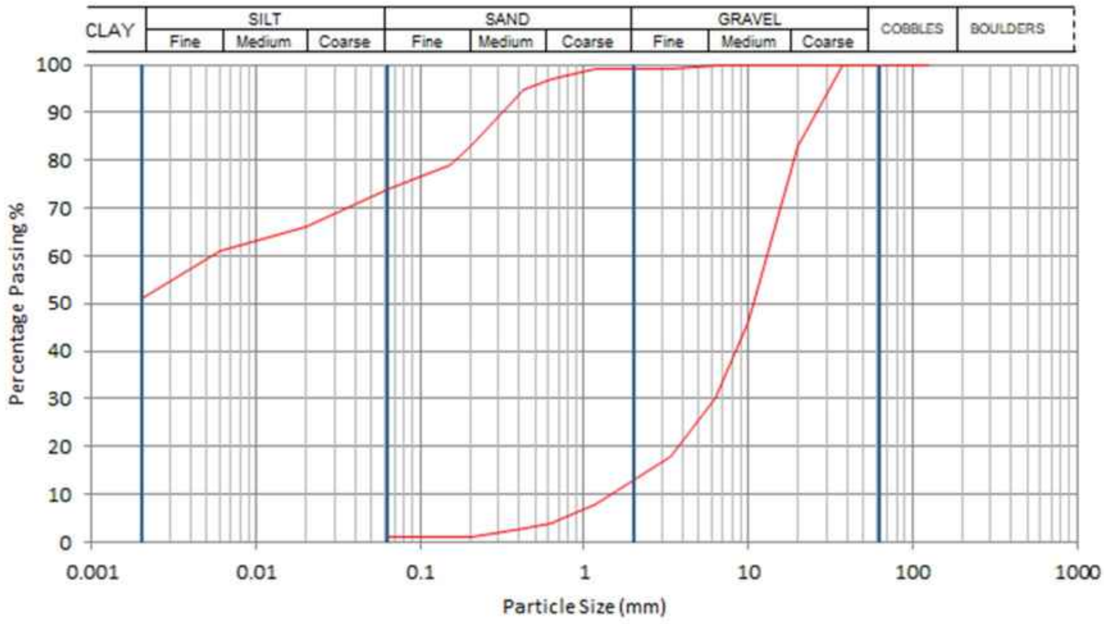
Based upon guidance provided within BS EN ISO 14688-2:2004 + A1:2013, the consistency index may be used to define the consistency of a material. The consistency index for the two samples is recorded as 0.00 and 0.61 respectively, indicating the material is on the border of its liquid limit in one case (very soft) and the remaining sample as firm. This does not fully align with the engineering logs which describe both materials as soft. It is possible this has been influenced by the organic content with the material indicated to be sensitive and will influence the materials engineering behaviour.

Three organic matter content tests were undertaken in the Granular Made Ground in RedP-BH1/1A, recording organic matter contents of 1.3%, 4.3% and 26.1% respectively. One organic matter content was also undertaken in TP222A, with a result of 0.3%. This would suggest the granular Made Ground has potential to for a variable organic matter content, ranging up to a high organic content in accordance with BS 5930:2015+A1:2020.

Two particle size distribution tests were undertaken in the Made Ground, presented in Figure 5.2. These indicate the following:

- Cohesive Made Ground – One test in cohesive Made Ground in BH501 indicates a slightly gravelly sandy CLAY, and correlates with the engineering log description of the material though its behaviour may tend to a silt based on plasticity testing.
- Granular Made Ground – One test within the Granular Made Ground at RedP-BH-1A indicated a sandy fine to coarse GRAVEL, correlating with the engineering log description. The grading of this material is similar to the underlying Marine Beach Deposits; therefore its possible Made Ground has been reworked from this material (see Section 5.5).

Figure 5.2: Made Ground – Particle size distribution testing



5.2.2 In-situ testing – SPTs

Two in-situ Standard Penetration Tests (SPT) were undertaken in the Made Ground.

It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, using the following equation:

$$N_{60} = \frac{E_r}{60} N$$

Where N = the blow count and Er = the Energy Ratio (63% and 75% respectively for the SPT hammers utilised in the GI).

In addition, Where SPT N values greater than 50 were recorded, results have been extrapolated in accordance with CIRIA R143 (1995).

The tests were undertaken in Granular Made Ground in RedP-BH-1, prior to termination of the hole due to encountering an obstruction. The extrapolated SPT N_{60} values were 9.5 and 210 respectively (the later test recording 50 blows for 75mm test penetration. This test encountered a concrete obstruction, and is therefore not considered representative for the material.

Based on BS5930:2015+A1:2020, this unit would classify as loose from its relative density.

5.3 Alluvium

Alluvium was recorded in proximity to the River Fromus in exploratory holes undertaken south of Saxmundham within BH501, BH502 and BH502A.

The unit was variable, encountered as a very loose to loose dark grey mottled black / greyish or orangish brown slightly to very clayey (locally gravelly) fine to coarse SAND, soft slightly sandy clayey SILT, or sandy silty CLAY. Occasional shell fragments were present, these are interpreted to be reworked from the underlying Crag Group.

It was encountered in thicknesses between 1.1 – 2.80m. It is possible this may not represent the maximum variation in thickness of Alluvium across the River Fromus, due to access constraints in where the exploratory holes could be undertaken on site. Reference should be made to Figure 4.2 which provides a geological section through this area.

It is also possible this unit has been reworked into the overlying Made Ground in BH501 (see Section 5.2 for further information).

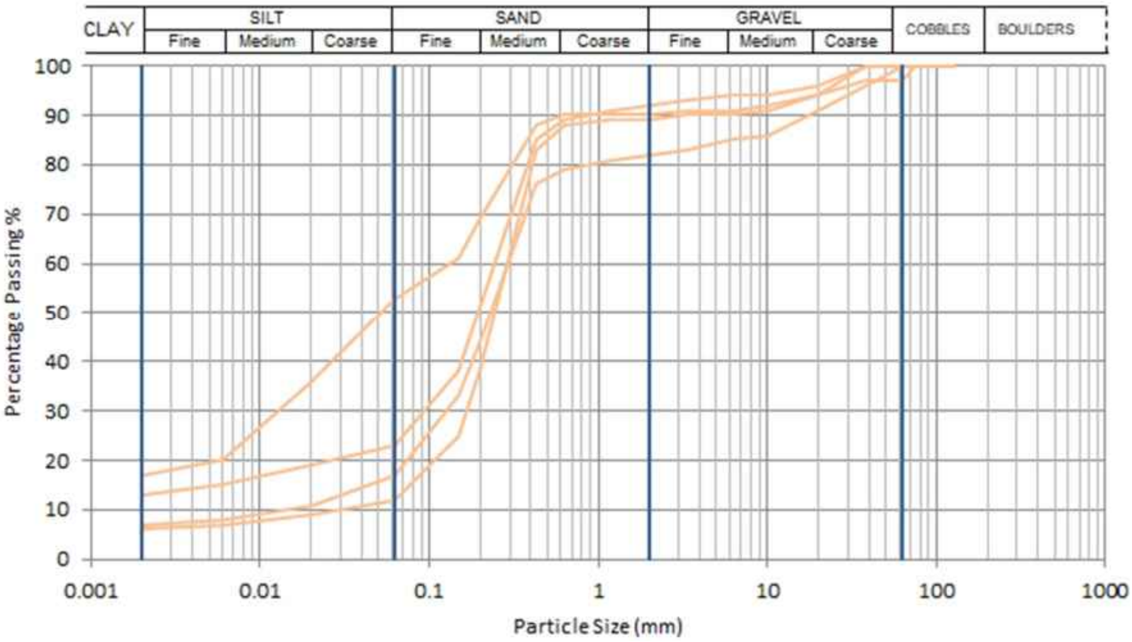
5.3.1 Soil classification testing

Limited soil classification testing undertaken within the Alluvium; the testing undertaken is summarised below.

Three moisture content tests were undertaken, with moisture content ranging between 14.9 to 29.5%.

Four particle size distribution tests were undertaken in the Alluvium, presented in Figure 5.3. These suggest the material ranges between a slightly gravelly sandy clayey SILT to slightly gravelly slightly silty / clayey SAND. This broadly correlates with the majority of engineering log descriptions. It is possible that the sand has been reworked by the river from the underlying Crag Group.

Figure 5.3: Alluvium – Particle size distribution testing



5.3.2 In-situ testing – SPTs

Three SPT tests were undertaken in the Alluvium. In accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values as detailed in Section 5.2.2.

One test was undertaken in a granular bed with a recorded SPT N value of 4, suggesting the material is very loose. This broadly correlated with the depth of groundwater during drilling.

The remaining two SPT tests were undertaken in cohesive materials, recording SPT N values of 8 and 10 respectively (SPT N_{60} of 10 and 12.5 respectively).

The undrained shear strength of the unit has also been calculated from SPT data using the equation presented within Stroud and Butler (1978) as described below. It should be noted that the correlation is intended for use on over consolidated clays, and should be treated with caution although provides an estimate of potential undrained shear strength.

A conservative f_1 value of 4.2 has been taken in absence of any plasticity index testing. This would suggest an undrained shear strength of approximately 42 – 52.5 kPa. Based on BS 5930:2015+A1:2020 this would indicate a strength classification of medium strength, and broadly suggests a greater strength than inferred from engineering log descriptions. It is likely that this has been influenced by the granular content of the material, although the results should be treated with caution as no other classification testing was undertaken in the cohesive Alluvium to review in conjunction with this.

5.4 Tidal Flat Deposits

The Tidal Flat Deposits were recorded near surface in vicinity of the Red Penguin HDD area, near the coast north of Aldeburgh.

The unit was recorded from 3.5m bgl in RedP-BH-01A as a very soft to soft grey mottled black CLAY with occasional shell fragments (1.7m thick), overlying a spongy fibrous black PEAT of 1.5m thickness. This unit was overlain and underlain by Marine Beach Deposits (see Section 5.5), which could suggest a change in environment associated with relative rises and falls in sea level.

5.4.1 Soil classification testing

Soil classification testing undertaken within the Tidal Flat Deposits is summarised below.

Table 5.3: Tidal Flat Deposits – Summary of classification testing

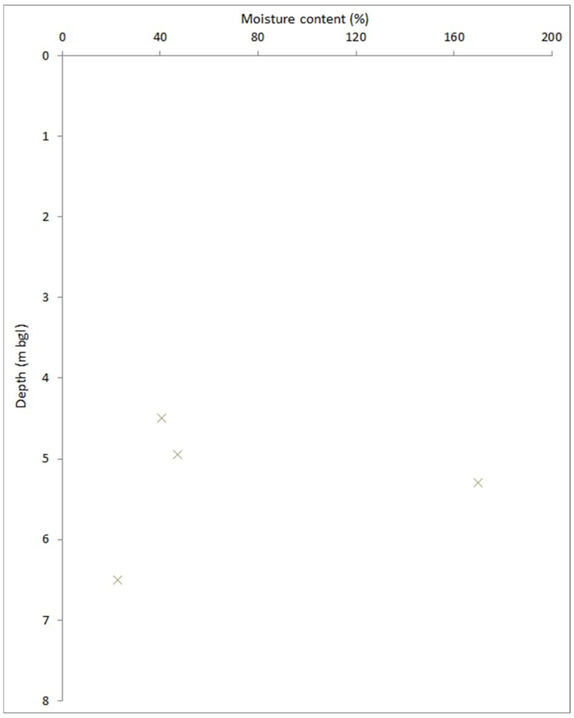
Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content (%)	4	22.6	170	70.1	43.9
Plastic limit (%)	1*	22			
Liquid limit	1*	46			
Plasticity Index (%)*	1*	24			
Consistency Index (Ic)	1	-0.05			
Bulk density (Mg/m^3)	2	1.79	2.03	1.91	1.91
Dry density (Mg/m^3)	2	1.28	1.66	1.47	1.47
Organic matter content (%)	1	23.4			

*Two plasticity tests were undertaken; one test was recorded as non-plastic and is therefore not summarised in the above table.

One organic matter content was undertaken in RedP-BH01A at 5.3m bgl, in material described on the engineering log as spongy fibrous black PEAT, with the sample recording an organic content of 23.4%

Four moisture content tests were undertaken, with moisture contents ranging between 22.6 to 170%, presented in Figure 5.4. These are likely to be elevated due to the presence of organic materials (including Peat where moisture content was recorded as 170%), and this correlates with the engineering log descriptions.

Figure 5.4: Tidal Flat Deposits – Moisture content versus depth

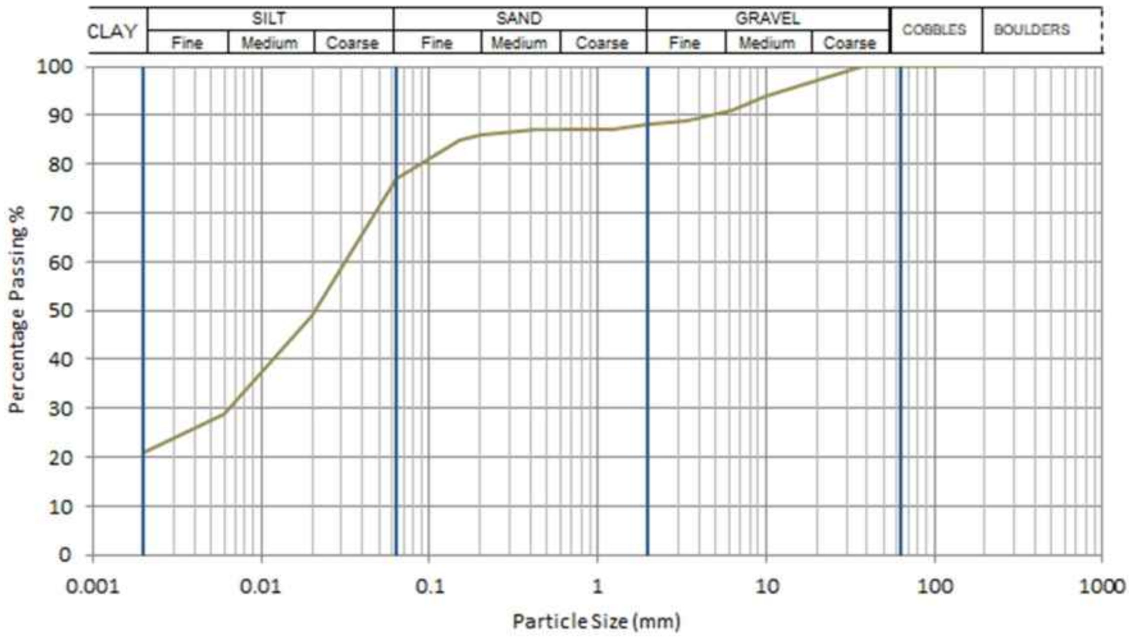


Two plasticity tests were undertaken, one of which was recorded as non-plastic in the Peat. The test in organic clay recorded a plasticity index of 24 indicating an intermediate plasticity clay.

Consistency index (calculated as per Section 5.2.1) within the one test undertaken indicates a value of -0.05, showing that the moisture content of the material exceeds its liquid limit and the material is sensitive, with its behaviour being influenced by organic content.

One particle size distribution test was undertaken, presented in Figure 5.5. This indicated the material to be a slightly gravelly slightly sandy silty CLAY and broadly correlates with the engineering log descriptions from the sample depth. The gravel content of this material is potentially attributed to shell fragments which were recorded on the engineering log.

Figure 5.5: Tidal Flat Deposits – Particle size distribution testing



5.4.2 In-situ testing – SPTs

Two SPT tests were undertaken in the Tidal Flat Deposits. In accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values as detailed in Section 5.2.2.

These recorded SPT N values of 4 and 11, and SPT N_{60} values of 4.2 and 11.6 respectively. The higher SPT N value correlates with the presence of Peat on the engineering logs, and it is possible the presence of fibrous organic materials may have influenced the test result.

The undrained shear strength of the unit has also been calculated from SPT data using the equation presented within Stroud and Butler (1978) as described below:

A conservative f_1 value of 4.2 has been taken based on the correlation between plasticity index (only one test result of 24 is available, therefore a conservative f_1 value is selected based on this), as presented in Stroud and Butler. This would suggest an undrained shear strength of approximately 17.6kPa and 48.5kPa respectively. Based on BS 5930:2015+A1:2020 this would indicate a strength classification of very low to medium strength. It is recommended that the result of 48.5kPa is treated with caution, as it may not be representative of the materials strength due to presence of fibrous organic materials which can influence the SPT tests.

5.4.3 Undrained shear strength testing

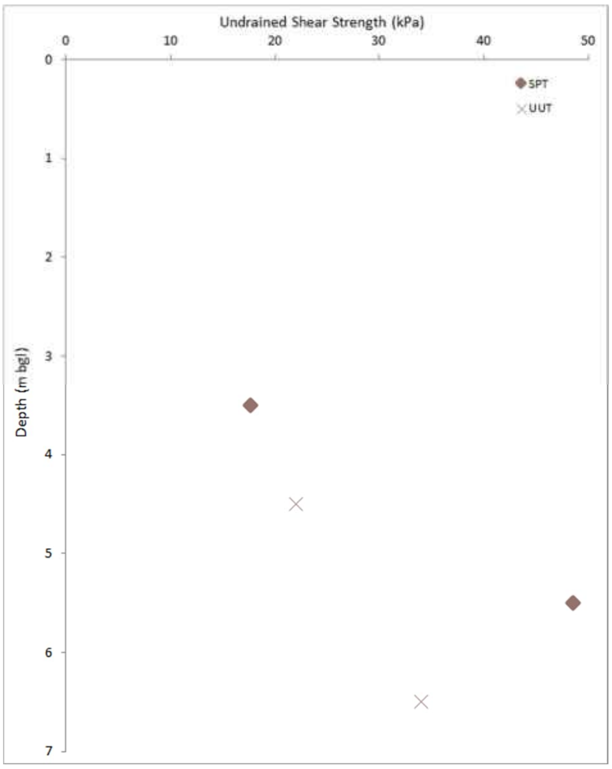
Direct measurement of undrained shear strength was undertaken in the form of two single stage unconsolidated undrained triaxial tests (UUT). These are summarised in Table 5.4, and in Figure 5.6 alongside the undrained shear strength derived from SPT testing, to review their relationship with depth and compare the undrained shear strength derived from different methodologies.

Both sets of data suggest a potential loose increase in strength with depth, and generally suggests a very low to low strength. The test suggesting a medium strength is not considered representative as it was undertaken in the Peat, as discussed above.

Table 5.4: Tidal Flat Deposits – Summary of undrained shear strength

Parameter	Source	No. of tests	Minimum	Maximum	Mean	Median
Undrained shear strength (kPa)	UUT	2	22	34	28	28
Undrained shear strength (kPa) derived from SPT N_{60} values	SPT	2	17.6	48.5	33.1	33.1

Figure 5.6: Tidal Flat Deposits – Undrained shear strength versus depth



5.5 Marine Beach Deposits

Marine Beach Deposits were encountered in RedP-BH-01A only (part of the Red Penguin HDD area of the site), and were recorded as a medium dense dark brown to dark grey mottled / multicoloured sandy GRAVEL with occasional shell fragments noted in the upper part of the unit. These were encountered from 1.5m bgl, with a thickness of 2.0m. They have also been interpreted to be present beneath the Tidal Flat Deposits in this borehole, where they were recorded at 2.75m in thickness and would potentially suggest a change in depositional environment throughout the Quaternary Period.

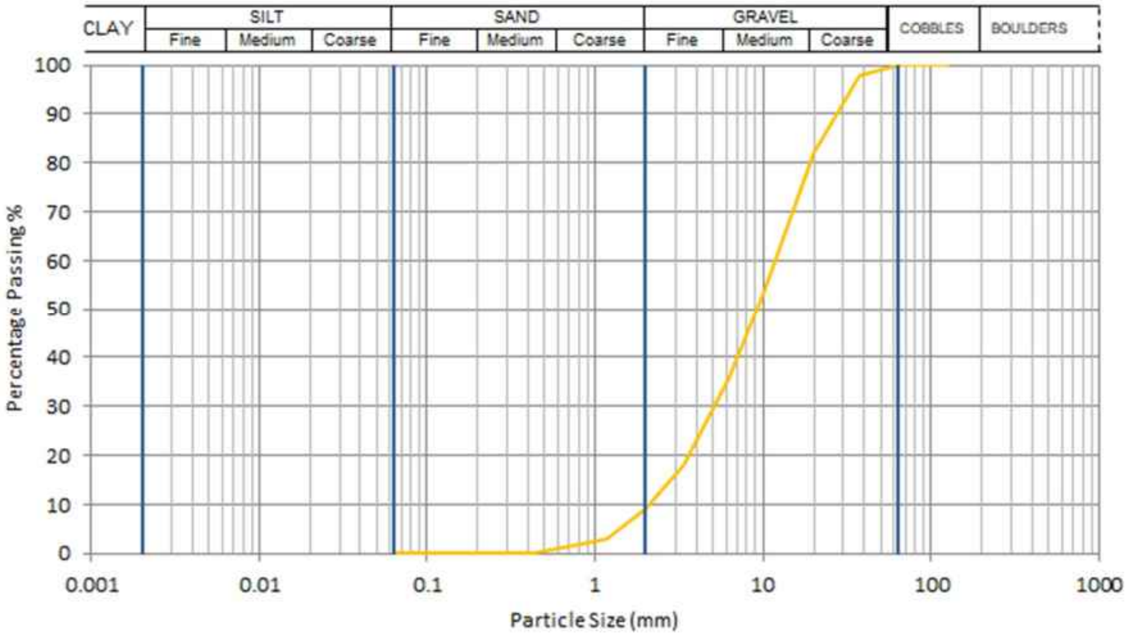
5.5.1 Soil classification testing

Limited soil classification testing was undertaken within this unit, and is summarised below.

One particle size distribution test was undertaken, indicating the material to be a slightly sandy fine to coarse GRAVEL, which was well graded. This correlates with the engineering log description. It is interpreted that the Marine Beach Deposits have been reworked into the Made

Ground recorded closer to the surface, with the PSD test presented in Figure 5.2 correlating with Figure 5.7, suggesting a similar grading and particle size.

Figure 5.7: Marine Beach Deposits – Particle size distribution testing



5.5.2 In-situ testing – SPTs

A total of four SPT tests were undertaken with the Marine Beach Deposits. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 5.2.2.

Table 5.5 summarises the results of the SPT testing for the Marine Beach Deposits. No distinct trend is observed due to the limited thickness of the deposits.

Based on the SPT N values in accordance with BS 5930:2015(+A1:2020), the unit is indicated to be medium dense.

Table 5.5: Marine Beach Deposits – SPT testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Red Penguin HDD	SPT N value	4	12.0	27.0	16.0	12.5
	SPT N_{60} value	4	12.6	28.4	16.8	13.1

5.6 Lowestoft Formation

The Lowestoft Formation is formed of several sub-units including the Diamicton, Sand and Gravel (which includes in some areas in the southern area of the district undifferentiated Kesgrave Group), and clay / silt based on the BGS 1:50,000 mapping. A schematic showing their potential inter-relationship is presented in Section 2.2, and their distribution across the site is captured in the project drawings detailed in earlier sections of this report and within Appendix A / B.

The Diamicton and the sand and gravel units of the Formation were the predominant units encountered at the site, and are described below. It should be noted that where thin, localised pockets/beds of granular material were recorded within the diamicton, these are presented in Section 5.6.3 where relevant (e.g. for DCP testing), and the sand and gravel sub-unit is mostly described in Section 6.6.2 e.g. where encountered along the length of the cable route and in greater thicknesses at depth at the Converter Station.

For preparation of this report, the Lowestoft Formation has broadly been treated as either Cohesive (reflecting the Diamicton) or Granular which reflects the sand and gravel, for assessment of in-situ and laboratory testing results. Any local variations associated with this are described below and within Section 4, including potential for clay and silt to be encountered within the Sand and Gravel (potentially associated with the Silt and Clay sub-unit of the Lowestoft Formation).

Information in this section is presented with respect to metres below ground level, to better reflect the information in relation to the proposed works.

5.6.1 Lowestoft Formation (Diamicton)

The Lowestoft Formation (Diamicton) was encountered across the site predominantly at the Converter Station and nearby areas of the cable route, as well as along Snape Road in vicinity of the proposed HDD crossing where the deposit is indicated to outcrop based on BGS mapping.

Converter Station

This unit was predominantly encountered as a soft or firm becoming stiff to very stiff locally friable yellowish brown (becoming bluish brown to dark grey) sandy slightly to gravelly CLAY with low cobble content. It contained occasional pockets and lenses of fine to coarse clayey or silty sand, rootlets (<3mm diameter) throughout, and rare pockets of silt / lignite, and boulders of Chalk. At the converter station this was between 7.9 – 9.0m in thickness, encountered beneath the topsoil at the site.

Occasional water bearing granular beds were encountered within this at the Converter Station as orangish brown clayey gravelly to very gravelly fine to coarse SAND to sandy angular to rounded GRAVEL of flint and Chalk with low cobble content. These were between c. 0 .25 – 0.55m in thickness.

Cable route (Snape Road)

In vicinity of Snape Road, the Diamicton is recorded on the 1:50,000 BGS mapping although was generally encountered as a clayey SAND up to c. 2.5 – 2.8m in thickness present overlaying (and in one instance also underlaying) soft to firm greenish brown (locally mottled orangish brown) or orangish brown sandy to very sandy CLAY. This was present up to 6.0m in thickness where proven.

As the thickness of the unit was only proven in BH203 and not within the nearby adjacent exploratory holes (TP203 or TP511), the relationship between these materials should be treated with caution in this area of the site. This does suggest potential variability within the material, which is expected based on its depositional environment and suggests it may be locally borderline in nature and becoming more granular in the central areas of the site

Other site areas – access roads, construction compounds

Diamicton was recorded along some of the access road locations including TP518 and TP525 north of the Converter Station site, as well as TP406 at the location of a proposed construction compound.

The description of the material broadly correlates with that described for the Converter Station, though locally the material tended to a SILT from 3.0m bgl in TP518, and in TP525 material below 1.2m bgl was recorded as a slightly gravelly very clayey SAND with occasional lenses of thinly laminated clay, and its thickness was not proven (>2.8m), suggesting a reasonable thickness of the sand and gravel member of the deposit. This has been described in Section 6.6.2.

5.6.1.1 Soil classification testing

A summary of the soil classification testing undertaken within the Lowestoft Formation (Diamicton) is presented in Table 5.6.

Table 5.6: Lowestoft Formation (Diamicton) – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content	93	10.0	35.1	19.3	19.2
Plastic limit	70[1]	15.0	41.0	22.9	22.0
Liquid limit	70[1]	27.0	72.0	49.5	48.0
Plasticity Index	70	9.0	48.0	26.6	25.0
Consistency Index[2]	70	0.72	2.02	1.16	1.13
Bulk density (Mg/m^3)	18	1.99	2.23	2.10	2.10
Dry density (Mg/m^3)	18	1.59	1.97	1.76	1.75
Carbonate content (%)	10	4.2	36.3	25.6	29.0
Organic matter content (%)	10	0.3	1.2	0.7	0.7

[1] One atterberg limit test was returned as non-plastic, and is therefore not summarised in the table.

[2] One consistency index was reported as –0.90, and is not considered representative for the material. This result is therefore not included in the above summary.

A total of ten organic matter content tests were undertaken, indicating ranges of organic matter content between 0.30 – 1.2%. The results indicate the material has an organic content lower than the defined limit for a 'low organic content' in accordance with BS 5930:2015+A1:2020.

The Lowestoft Formation is known to be a chalky till containing relatively high percentages of carbonates, and ten carbonate content tests were scheduled to review this. These are presented in Figure 6.9. Literature suggests it may be decalcified near its surface, although only two results suggested slightly lower carbonate content near the top of the unit.

Eighteen measurements of bulk and dry density were taken from undisturbed samples, summarised in Table 6.6 and presented in Figure 6.10. There is a loose increase in bulk and dry density with depth observed as well as a reasonable range of values recorded, with bulk density ranging between approximately 1.99 – 2.23 Mg/m^3). This range may be associated with the unit's variability and sand / gravel content. The results would infer a range of strength between approximately medium to very high strength based on correlations in BS 8004:2015(+A1:2020), which broadly correlates with the inferred strength from engineering log descriptions.

Figure 5.8: Lowestoft Formation – Diamicton – Carbonate content versus depth

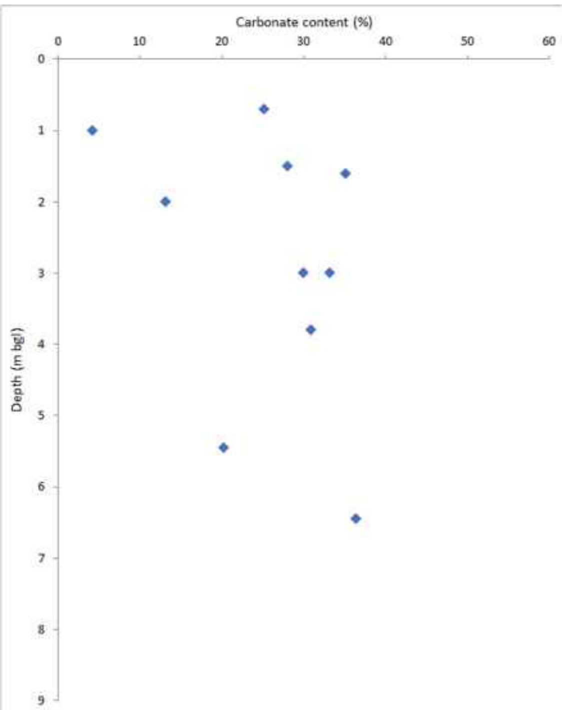
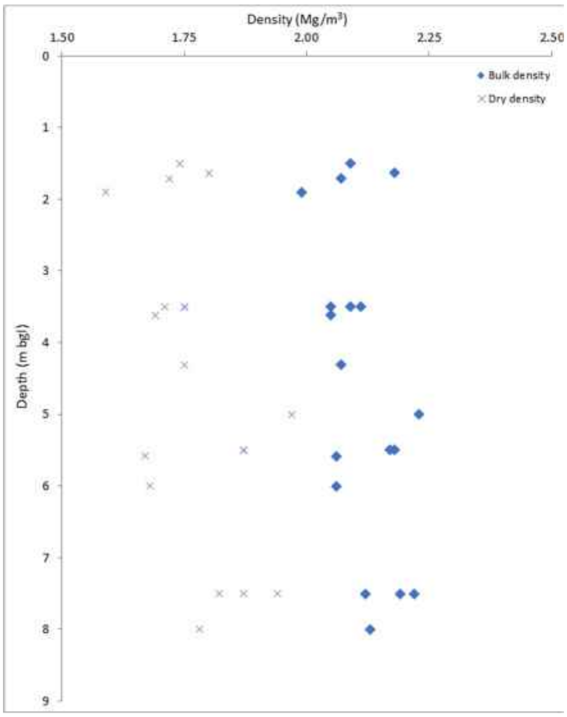


Figure 5.9: Lowestoft Formation – Cohesive – Density versus depth



A series of ninety-five moisture content tests were undertaken at the site in the unit, presented in Figure 5.11. These record a reasonable variation in the units moisture content with depth, with an overall very loose trend of decreasing moisture content with depth observed from c. 2.5m bgl. Nearer surface, moisture content is more variable, and there are some results which suggest lower moisture contents than the majority of testing between c. 10 – 15%, which roughly correlate with areas of increased granular content from the engineering log descriptions.

Liquid limit, plastic limit and moisture content is shown in Figure 5.12, with moisture content generally below or close to the plastic limit suggesting the material is moisture deficient. This correlates with the engineering logs for the material which generally describe this as firm to very stiff.

Figure 5.10: Lowestoft Formation – Diamicton – Moisture content versus depth

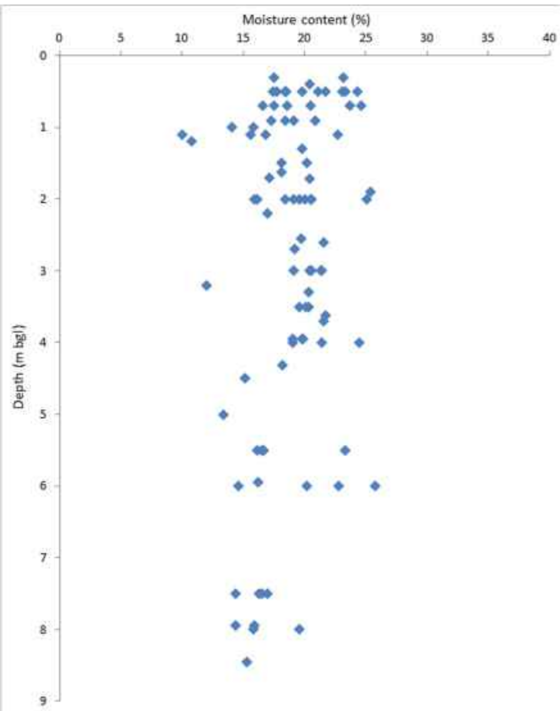
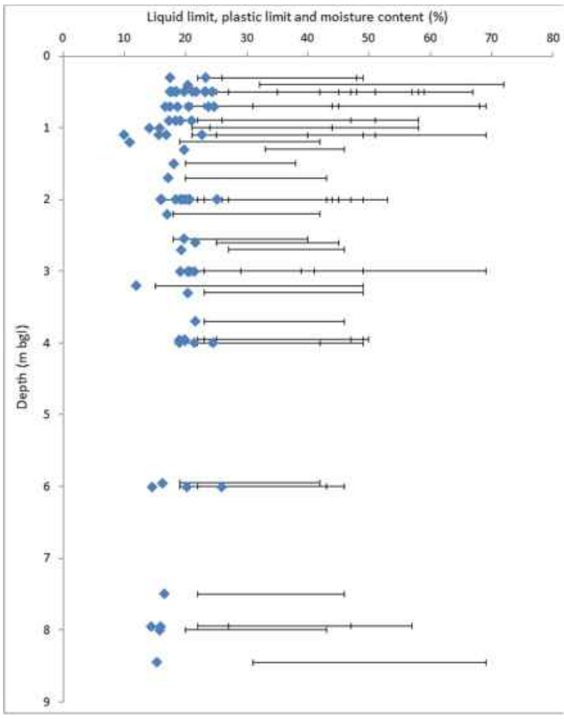


Figure 5.11: Lowestoft Formation – Diamicton – Liquid limit, plastic limit and moisture content versus depth



Plasticity index is presented in Figure 5.13 and shows potential trends with depth in the Diamicton. In the uppermost metre of the deposit, a larger range in plasticity index is observed and this variability in behaviour appears to loosely decrease with depth, though fewer tests are undertaken and therefore this should be treated with caution. A few plasticity tests in the uppermost 3 metres record lower plasticity indices than the remaining testing (e.g. TP204, TP316, TP518, circled in red in Figure 5.13), these appear to correlate with observations of increased silt content such as silt pockets or where the Diamicton locally grades to a silt, which helps explain these results.

Consistency index has been calculated as per the equation in Section 5.2.1, and is presented in Figure 5.14. This generally indicates the material to be stiff to very stiff, with local pockets which may be firm. This broadly correlates with the majority of engineering log descriptions which describe the material as stiff to very stiff, though engineering logs note it may locally be soft / firm.

The A-line plot for the Diamicton is presented in Figure 5.15, and shows that the unit is generally of intermediate to high plasticity, and may locally be low or very high plasticity clay, or locally tend to intermediate to high plasticity silt. This broadly correlates with the engineering log descriptions, and reflects the variability in behaviour due to its formational processes. No distinct spatial relationship was observed across the site, with the vast majority of testing undertaken in vicinity of the Converter Station.

Figure 5.12: Lowestoft Formation – Diamicton – Plasticity index versus depth

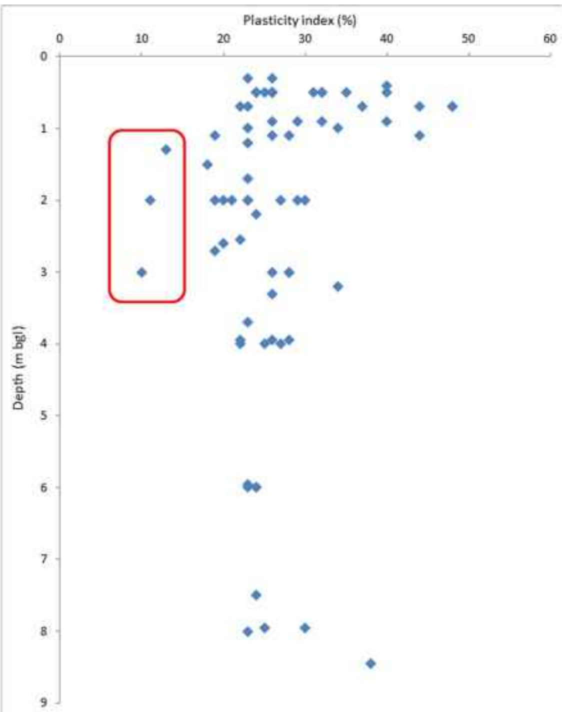


Figure 5.13: Lowestoft Formation – Diamicton – Consistency index versus depth

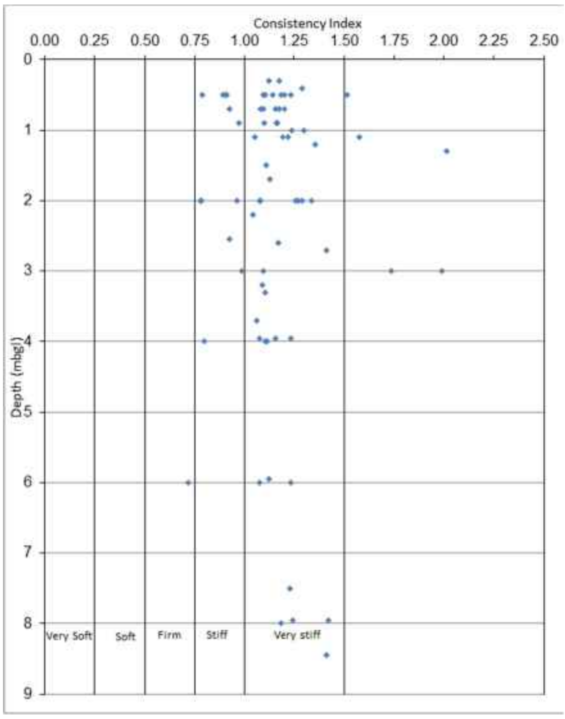
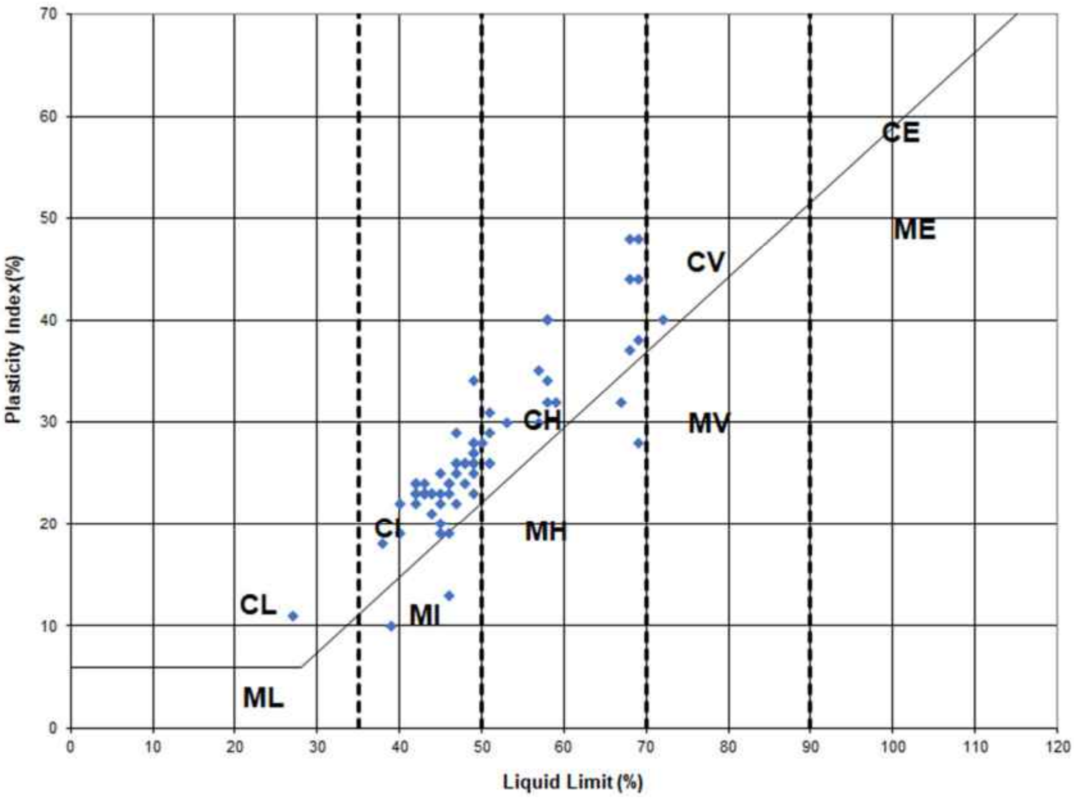
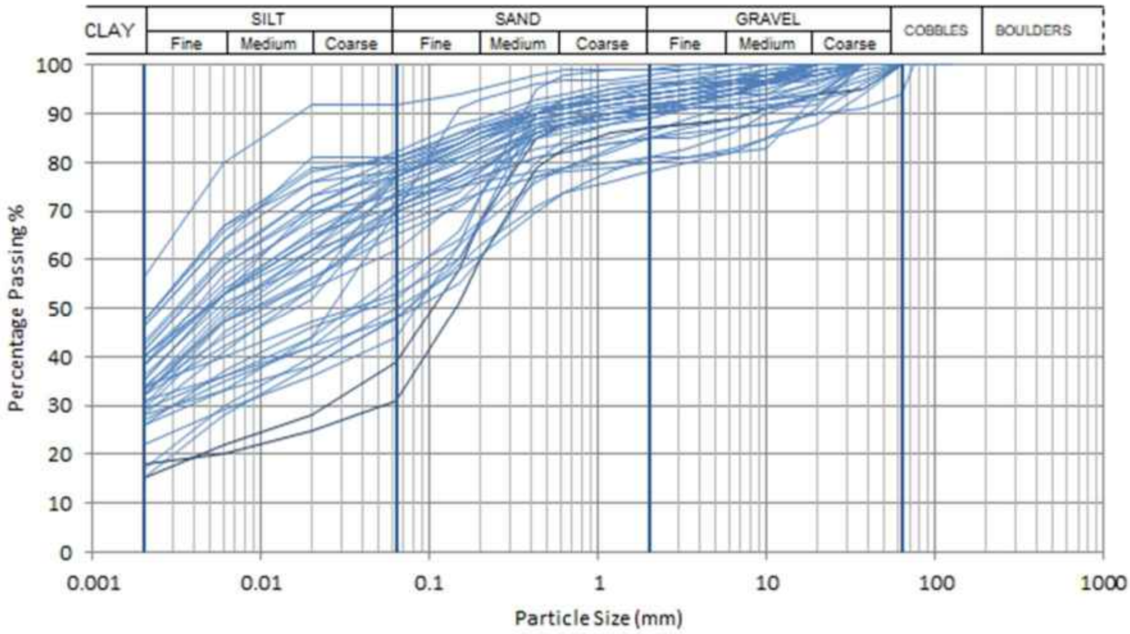


Figure 5.14: Lowestoft Formation – Diamicton – A-line plot of plasticity index versus liquid limit



Forty three particle size distribution tests were undertaken within the Diamicton, presented in Figure 5.16. These indicate the material to be a slightly to gravelly slightly to very sandy silty clay, locally potentially tending to clayey silt. These tests broadly correlate with the range of descriptions observed on the engineering logs and engineering behaviour suggested in the A-line plot in Figure 5.15. The material was encountered with a greater sand content in vicinity of Snape Road, suggesting its composition may change across the footprint of the site, with two test results undertaken here presented in a darker shade of blue, correlating with the engineering log descriptions.

Figure 5.15: Lowestoft Formation – Diamicton – Particle size distribution testing



5.6.1.2 In-situ testing - SPTs

A total of nineteen SPT tests were undertaken with the Diamicton. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 5.2.2. Results have been extrapolated in accordance with CIRIA R143 (1995).

Table 5.7 summarises the results of the SPT testing for the Lowestoft Formation (Diamicton), with results presented in Figure 5.16. The SPT N values are broadly shown to increase with depth at the Converter Station and correlate with the engineering log descriptions and consistency classification testing suggesting the material is stiff / very stiff. In addition, relevant SPT tests undertaken as part of the SPR project are presented in Figure 5.16 and are shown to broadly correlate with the test results observed.

Only one test was undertaken in the Diamicton at Snape Road. In this location, as discussed in Section 5.3, the unit was more variable than the Diamicton encountered at the Converter Station. The unit was broadly more granular (see particle size distribution above) and contained a greater sand content, as well as being interbedded with sands (assessed as part of Section 5.6.2).

Undrained shear strength can be calculated from SPT data using the equation presented within Stroud and Butler (1978). This correlation has been derived for over-consolidated clays, similar to the material encountered at the site, and should therefore provide a conservative estimate of undrained shear strength. A conservative f_1 value of 4.2 was taken based on the correlation between plasticity index (a conservative plasticity index of 40 was selected due to the range of plasticity behaviour observed) as presented in Stroud and Butler.

Table 5.7: Lowestoft Formation (Diamicton) – SPT testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Snape Road HDD	SPT N value	1		10		
	SPT N_{60} value	1		10.5		
	Undrained Shear Strength (kPa) from SPTN_{60} values	1		44.1		
Converter Station	SPT N value	20	15.0	45.0	30.7	32.0
	SPT N_{60} value	20	18.8	56.3	37.4	37.5
	Undrained Shear Strength (kPa) from SPTN_{60} values	20	78.8	236.3	157.2	157.5

Undrained shear strength for the unit ranged between c. 78to 236kPa, suggesting the unit is medium to very high strength in accordance with BS 5930:2015+A1:2020. The results correlate with trends and data observed within soil classification testing, strength inferred from bulk density testing and the engineering log descriptions.

Figure 5.16: Lowestoft Formation (Diamicton) – SPT N_{60} value versus depth

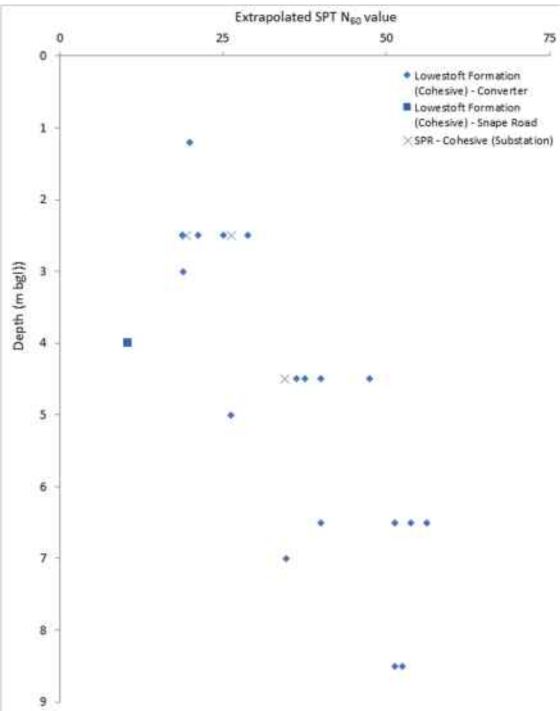
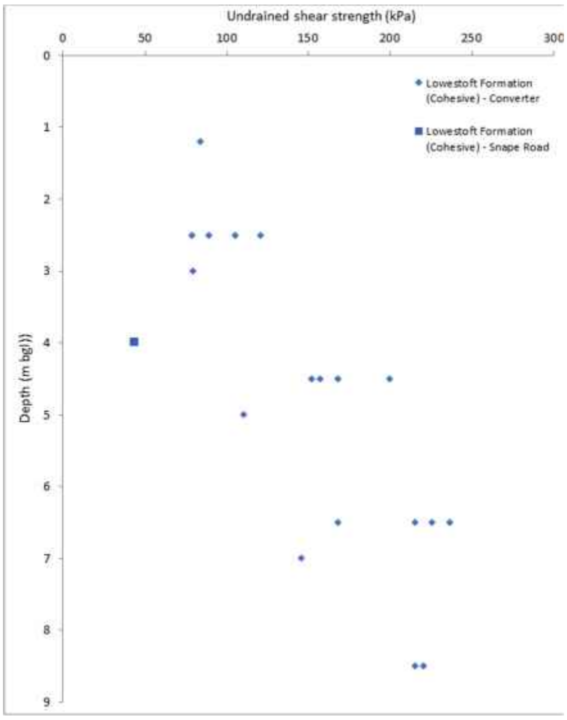


Figure 5.17: Lowestoft Formation (Diamicton) – Undrained shear strength from SPT N_{60} versus depth



5.6.1.3 In-situ testing – Hand vane testing

A series of hand vane tests were undertaken within suitable sub samples from the ground investigation either within inspection pits or from suitable material excavated from trial pits. These were undertaken to provide an indication of undrained shear strength, however should not be relied upon as a direct measurement.

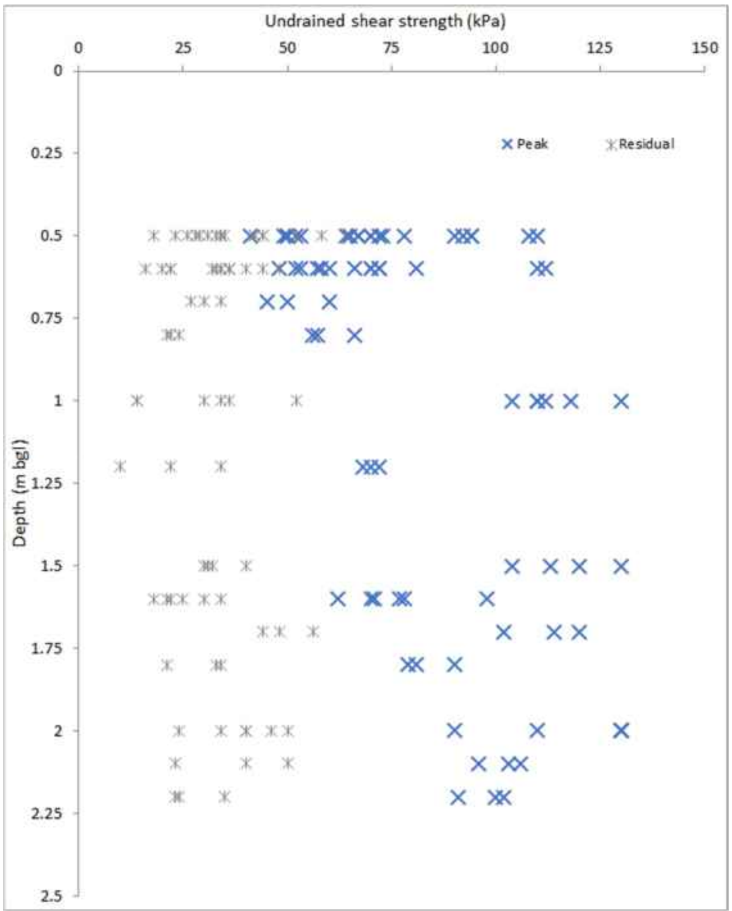
A summary of the results is presented in Table 5.8, and shown in Figure 5.18. These were generally undertaken as a set of three readings at the same depth based on (BS EN ISO 22476-9:2020). It was not always possible to undertake these tests in the Diamicton as often it was recovered as a very stiff friable material, with no suitable sub samples to test. In addition, the hand vane was not sufficient to measure the shear strength on two tests where undrained strengths exceeded 130 – 160kPa, and as a result these have not been discussed further.

The results suggested a range of peak strength between 41 – 130 kPa, which would indicate a medium to high strength based on BS 5930:2015+A1:2020, correlating with observations of strength from other in-situ methods including SPTs (see Section 6.6.1.2). The inferred residual strengths range between c. 10 – 64kPa, suggesting it may be a low to medium strength material once remoulded.

Table 5.8: Lowestoft Formation (Diamicton) – Hand-vane testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Site wide	Peak undrained shear strength	81	41	130	83.7	78
	Residual undrained shear strength	80	10	64	33.3	34.0

Figure 5.18: Lowestoft Formation (Diamicton) – In-situ hand vane undrained shear strength versus depth



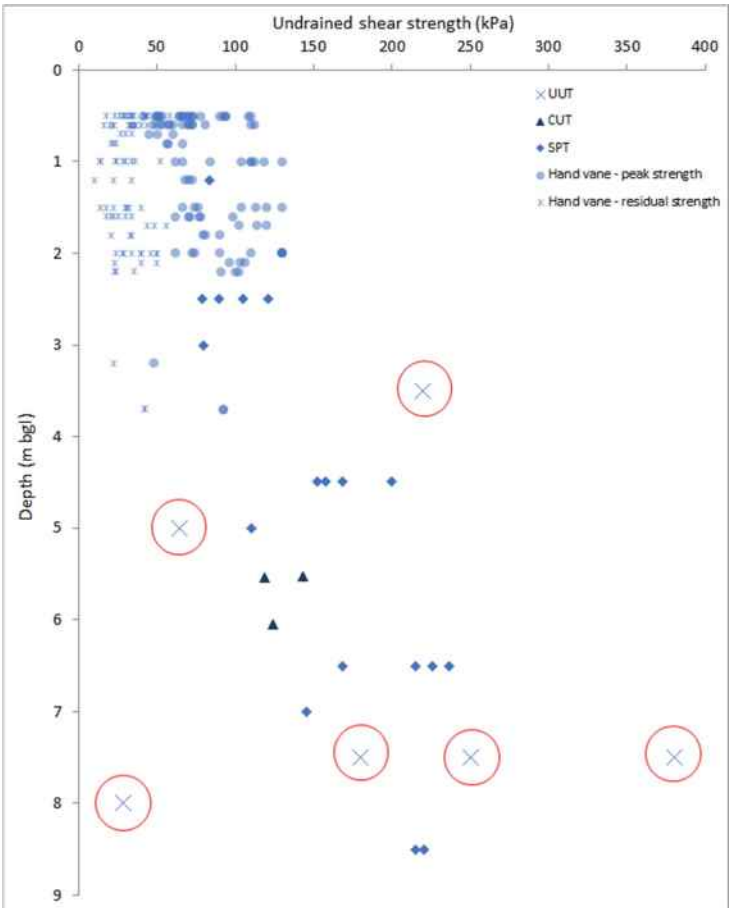
5.6.1.4 Undrained shear strength laboratory testing

Direct measurement of undrained shear strength was undertaken in the form of ten single stage Unconsolidated Undrained Triaxial (UUT) tests, as well as three Consolidated Undrained Triaxial (CUT) tests. These are summarised in Table 5.9 and Figure 5.19, alongside the undrained shear strength derived from SPT testing to review their relationship with depth and compare the undrained shear strength derived from different methodologies.

Table 5.9: Undrained shear strength testing summary

Parameter	Source	No. of tests	Minimum	Maximum	Average	Median
Undrained shear strength	UUT	10	28	380	168.2	155.
Undrained shear strength	CUT	3	119	143	128.7	124
Undrained Shear Strength (kPa), derived from SPT N_{60} values	SPT	18	78.8	236.3	153.9	154.9
Undrained shear strength	Peak – hand vane	81	41	130	83.7	78
	Residual – hand vane	80	10	64	33.3	34.0

Figure 5.19: Lowestoft Formation – Diamicton – Undrained shear strength testing versus depth from different testing methodologies



The UUT test data records a wider range of shear strength at depth than observed within SPT testing, this could potentially be a function of presence of reasonable coarse granular content in the material. Consultation with the Contractor's laboratory and remarks on test sheets indicated that 60% of the samples failed sample preparation checks related to flatness and/or perpendicularity during the test preparation stage, likely attributed to the presence of variable coarse granular content including potential for gravel sized fragments in the material (samples circled in red within Figure 5.19). The tests were proceeded by the laboratory with the acknowledgement of potential limitations associated with their results due to failure of these checks.

This is broadly supported by photograph observations in three samples which were split and described by the laboratory, with photographs presented in Figure 5.20 and indicate presence of granular content which may influence the test preparation and the test results. However, for the three CUT tests these all record fairly similar undrained shear strengths.

Figure 5.20: Lowestoft Formation – Diamicton – UT100 split and describe photographs

Consolidated Undrained Triaxial testing

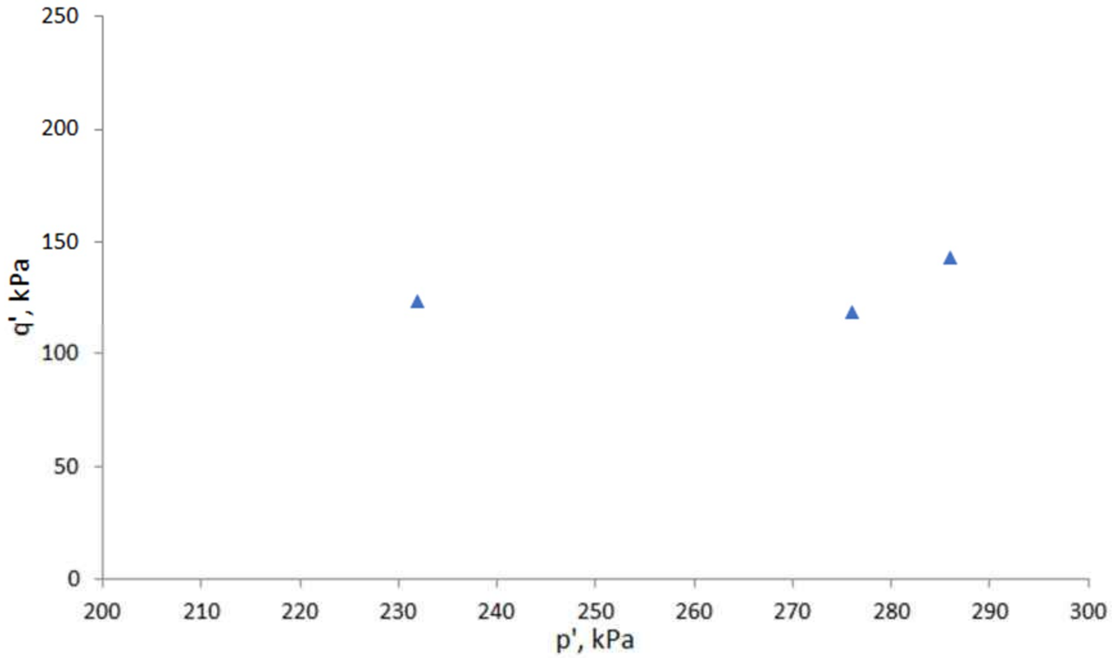
A summary of the effective stress properties derived from the three single stage CUT tests are summarised below.

To allow comparison of the effective stress tests conducted, the p’ and q’ were calculated for each test. Calculation of the p’ and q’ used the following equation:

$$p' \frac{\sigma_1 - \sigma_3}{2}, and q' \frac{\sigma_1 + \sigma_3}{2}$$

Due to limited data as the tests were single stage only, it is difficult to determine representative shear strength parameters. However, assuming a value of cohesion of between 0 to 2.5kPa (it is likely that a small amount of cohesion will apply to glacial till based on its engineering description and typical properties of the material), then an effective angle of shearing resistance of between approximately 29.3 – 30.5 is calculated. This should be treated with caution due to the range of loads the samples were tested over, which may make it difficult to determine the angle of shearing resistance and cohesion with more confidence.

Figure 5.21: Lowestoft Formation (Diamicton) – p' versus q' from CUT testing

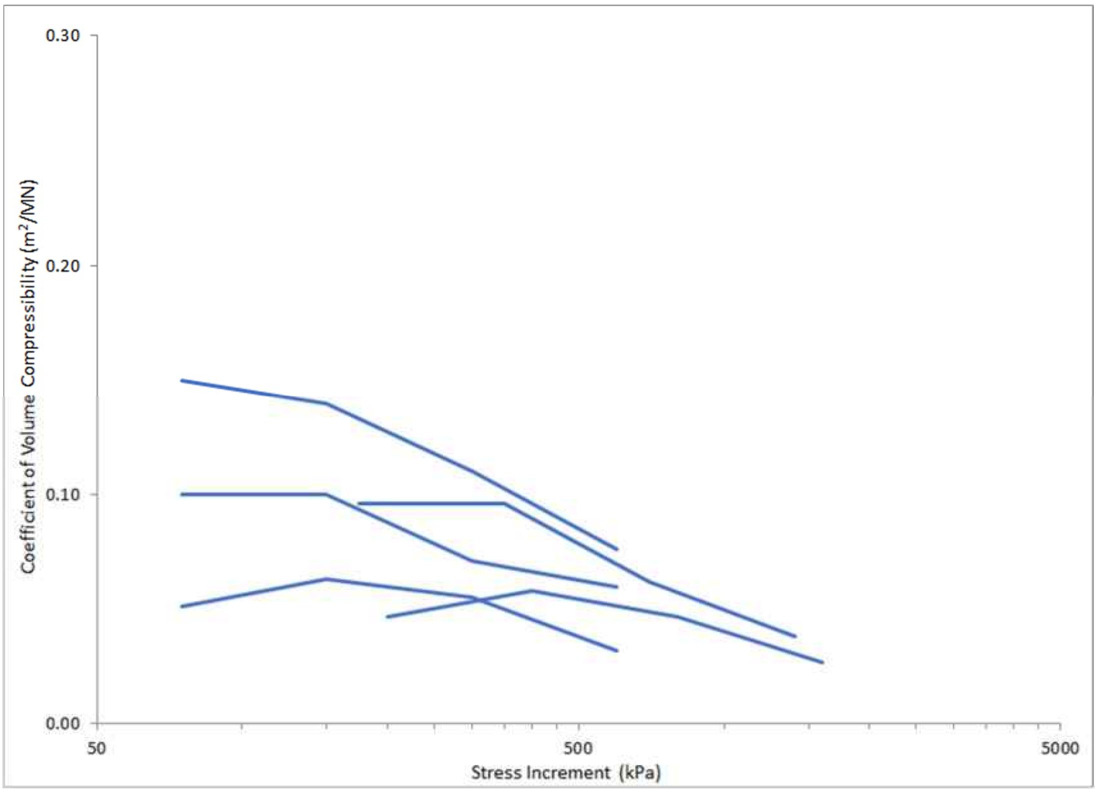


5.6.1.5 Consolidation testing

Five one-dimensional consolidation tests were undertaken to measure the compressibility and consolidation coefficients of the Lowestoft Formation (Diamicton) at the Converter Station site. These are presented in Figure 5.23 and Figure 5.23.

The m_v values determined from oedometer testing suggest the unit has a medium to low compressibility, which is typical of firm to stiff overconsolidated clays. These observations correlate with soil classification testing presented above.

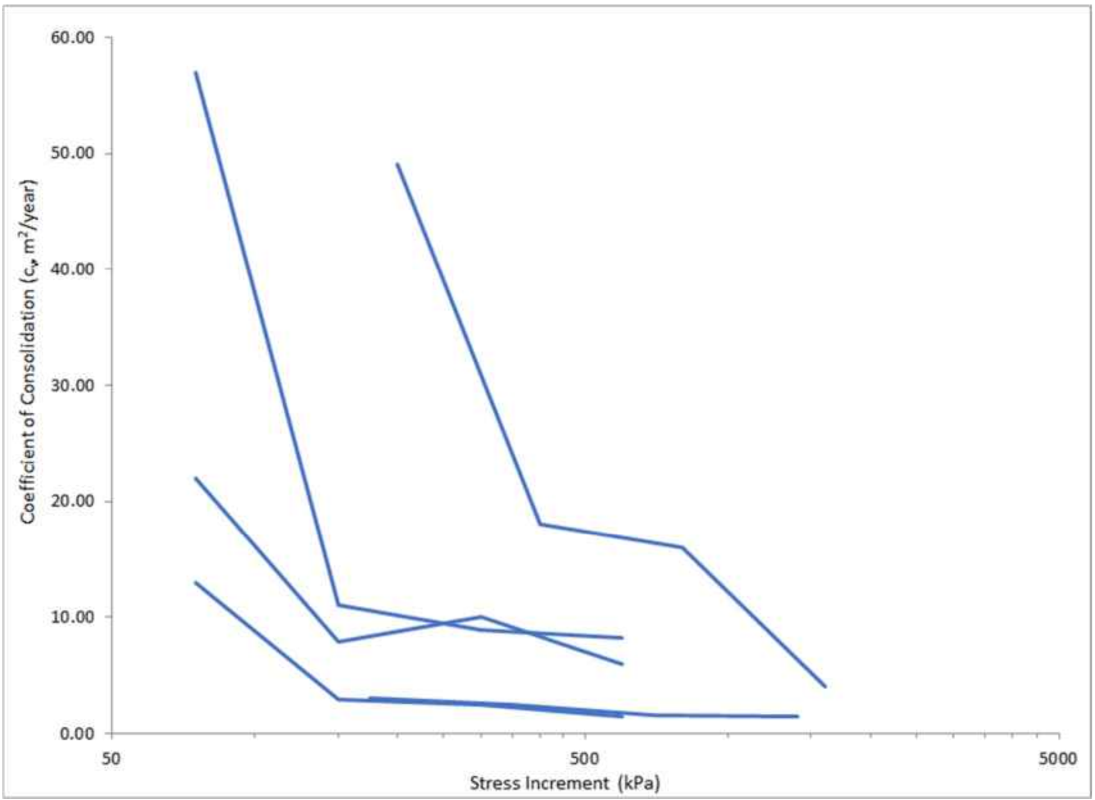
Figure 5.22: Lowestoft Formation (Diamicton) – Coefficient of volume compressibility versus stress increment



The coefficient of consolidation, c_v , derived from the root time method has been assessed against stress increment and is shown in Figure 5.23.

There is large variation shown in c_v, although most tests record values of between 1.4 – 10 m^2/year above test pressures of c. 150kPa. Due to this variability it is recommended that they are treated with caution. It should be noted that generally the rate of settlement observed for full scale structures is much greater than estimates from laboratory testing.

Figure 5.23: Lowestoft Formation (Diamicton) – Coefficient of consolidation versus stress increment



5.6.1.6 Earthworks

A series of earthworks relationship tests were undertaken in accordance with BS 1377-2 (2022), including compaction tests utilising a 2.5kg compactive effort with an assumed particle density of 2.68 Mg/m^3, laboratory California Bearing Ratio (CBR) and Moisture Condition Value (MCV) tests. The CBR and MCV tests were generally undertaken at the same moisture content as the corresponding compaction test to investigate the relationships between these properties.

It should be noted that in many instances samples were combined over the strata depth to provide sufficient sampling material for the required laboratory testing. It is not thought that this is likely to have a significant impact on the test results presented based on the engineering descriptions of the material, and may potentially reflect conditions during construction dependent on the required depth of cut and fill.

A summary of the testing undertaken is presented in Table 5.10 and Figure 5.25, and is described in more detail below. It should be noted that for the purpose of Table 5.10 the full range of results of CBR and MCV tests are reported over the compaction relationship, hence a large variation in the test results is observed.

Table 5.10: Lowestoft Formation (Diamicton) – Earthworks classification testing summary

Compaction

Test type	No. of tests	Maximum Dry Density (Mg/m^3)			Optimum Moisture Content (%)		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Light compaction (2.5kg rammer)	14	1.64	2.00	1.76	11.0	21.0	16.9

California Bearing Ratio

Test type	No. of tests	Minimum	Maximum	Average	Median	Remarks
Laboratory CBR relationship test	14	0.90	55.0	12.7	9.8	Full relationship tests not always possible on all samples. E.g. samples which were prepared too wet of optimum

Moisture Condition Value

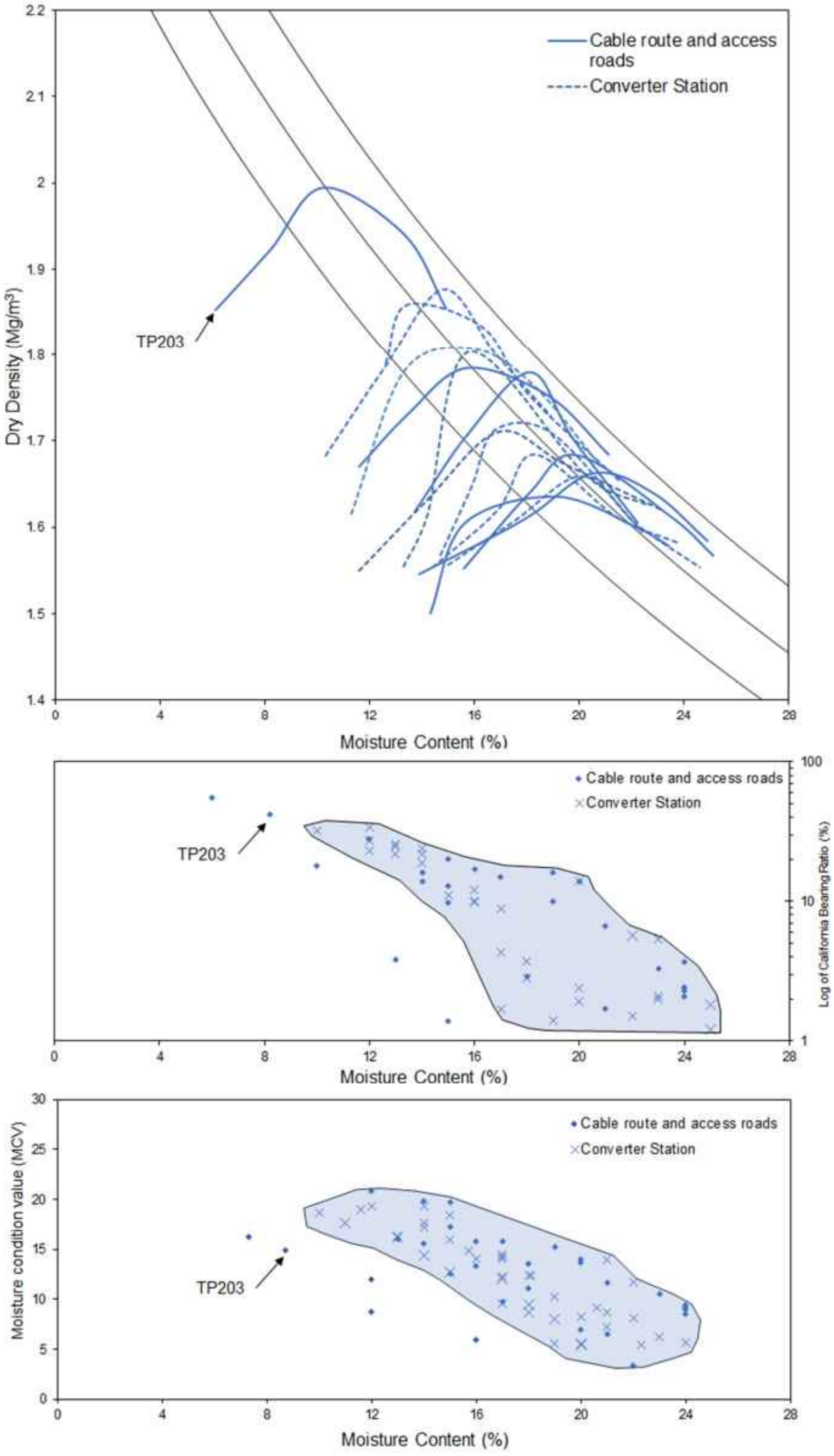
Test type	No. of tests	Minimum	Maximum	Average	Median	Remarks
Laboratory MCV test	14 (sets of tests)	3.4	20.8	12.4	12.5	Full relationship tests not always possible– e.g. sample mass limitations

The relationship testing presented in Figure 5.24 shows some variation in the behaviour of the material. One compaction test records a greater dry density and lower optimum moisture content than the remaining tests, and was located at TP203 which is an area of the site where a noticeable increase in granular content of the unit was recorded, and is likely to be responsible for the results shown (see particle size distribution test plot). Excluding this test result which recorded an optimum moisture content of 11%, the optimum moisture contents elsewhere range between 14 – 21%, with the variation likely attributed to the variable make-up of the material including granular content, although no significant variation is observed between the converter station and cable route / access roads except for TP203 discussed above. Compaction to approximately 5% air voids was achievable around the optimum moisture content of the material. The in-situ moisture content over the depth of earthworks testing broadly ranges between 10 – 24.5%, suggesting that the material generally sits around the optimum moisture content so it is feasible to re-use, subject to an element of either wetting or drying, dependent on its existing condition.

The CBR testing indicated a reasonable variation of results from the testing shown. CBR is generally greater at lower moisture contents with a trend of decreasing CBR with increasing moisture content as expected. Over the range of optimum moisture content (14 – 21%), CBR is shown to vary between c. 1.4 – 22%. This is likely to be influenced by the variability in the unit and granular content and may suggest that some of the unit could be untrafficable and require treatment such as drying.

MCV testing records a similar trend to CBR testing with values decreasing with increasing moisture content. Over the range of optimum moisture content, MCV ranges between 5.6 – 19.7, and the variation shown is likely to be attributed to variations in composition and granular content similar to other relationship tests described above. As discussed above, testing associated with TP203 is shown outside the hatched area, and reflects an area of increased granular content of the Diamicton and the testing shown correlates with it displaying a lower optimum moisture content, and correlates with the particle size distribution test from this location.

Figure 5.24: Lowestoft Formation (Diamicton) – Earthworks relationship testing



5.6.2 Lowestoft Formation (Sand and Gravel)

The Lowestoft Formation (Sand and Gravel), also referred to as the granular component of the formation within this report, was predominantly encountered in the 2023 GI beneath the Diamicton at the Converter Station, along the Cable Route and in the eastern half of the site where the Diamicton is absent (see Section 2.2 showing a schematic of the relationship between units within the Lowestoft Formation), and broadly correlated with its distribution identified on BGS mapping (see Appendix A). Localised granular beds were also recorded at the top of the Diamicton or within it in some instances, and these are discussed in detail within the ground models summarised in Section 4 / Appendix B. A high-level summary of the descriptions of this material across the site is presented in Section 4, with more detailed summaries across different areas of the site captured within Appendix B.

This unit has been interpreted to be present beneath the Diamicton based on information presented in Sections 2 – 4, though it is difficult to distinguish between the Sand and Gravel and underlying Crag Formation with certainty and therefore information presented in this section from the Converter Station should be treated with caution.

It was generally recorded as a slightly to clayey/silty slightly to gravelly fine to coarse SAND with variations in fines/gravel content, as well as the cobble content of flint.

Locally the material was also contained beds of very sandy SILT (TP218) or was described as a slightly gravelly sandy silty CLAY in one location (TP204), suggesting it may locally vary to cohesive behaviour and may reflect variable deposition during its formation, which appear to be associated spatially with the central areas of the cable route. In this same area of the site, the Diamicton is indicated to be more granular.

It's possible that in these areas the silt and clay component of the Lowestoft Formation may have been encountered, though it was not indicated as being present based on the available BGS mapping and should therefore be treated with caution. Reference should be made to Appendix B which covers the range of material descriptions in more detail.

5.6.2.1 Soil classification testing

The soil classification testing undertaken in the Lowestoft Formation – Sand and Gravel is summarised below. It should be noted that this unit has been interpreted to be present based on review of engineering logs alongside available BGS information, though it is possible due to the variable formation environment some of the materials described below could potentially represent local variations to other sub-units of the Formation (e.g. silt and clay).

Table 5.11: Lowestoft Formation (Sand and Gravel) – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content***	34	4.5	43.9	14.7	14.1
Plastic limit*	4	19	31	23.3	22
Liquid limit*	4	27	48	39.8	42
Plasticity Index*	4	9	23	16.5	17
Consistency Index*,**	3**	1.22	2.54	1.95	12.09

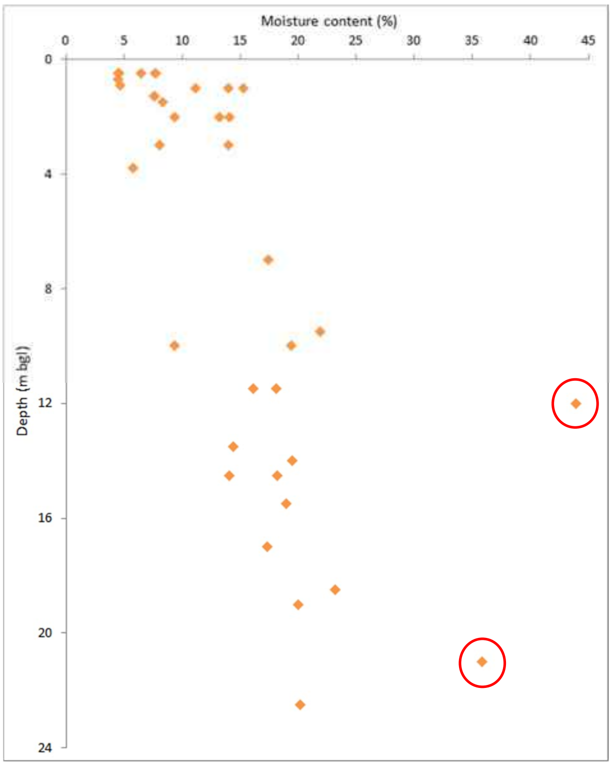
*Four additional atterberg limit tests were undertaken, however these indicated the material to be non-plastic and are therefore not reported.

**One result recorded a consistency index of -0.90 though this is considered misrepresentative as the material was recorded as very stiff on the engineering log, and may have been influenced by sampling below the groundwater table.

***One test result (BH307 at 16m bgl) recorded a greater moisture content and a consistency index of -0.90. This is not thought to be representative and contradicts the engineering log which described the material as very stiff, and is therefore not discussed further.

A series of moisture contents were undertaken in the unit, presented in Figure 5.25. All tests presented below 8m bgl were undertaken at the Converter Station, with shallower testing also undertaken across the full site. Moisture content broadly is shown to increase with depth, with results at depth (below 8m bgl) broadly reflecting tests undertaken where water was added to assist drilling. Therefore, results below this depth should be treated with appropriate caution as they won't be representative of natural conditions. It is likely that any groundwater strikes were masked during drilling by addition of water. It is likely that groundwater has influenced several of the tests including results of 35.8% and 43.9% (circled in red) and these results should therefore be treated with caution with one result relating to cohesive material present at depth.

Figure 5.25: Lowestoft Formation – Sand and Gravel – Moisture content versus depth

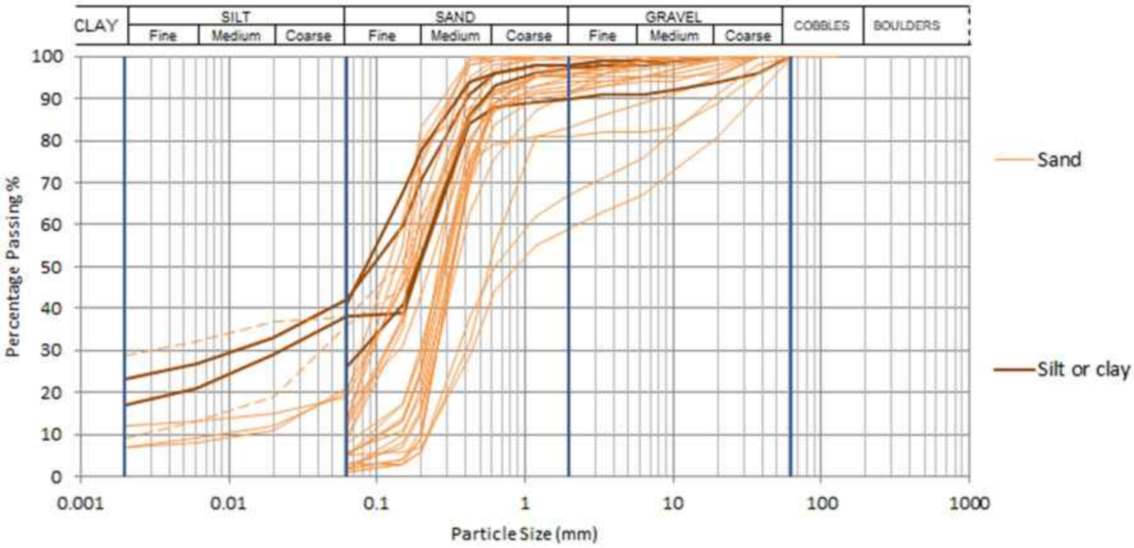


Two atterberg limit tests were undertaken in TP204, where the unit was locally described as a firm to very stiff sandy silty CLAY which contained occasional pockets of soft silt. These indicated plasticity indices of 11 and 23 respectively and based on the A-line plot, suggest the material is an intermediate plasticity clay to silt, correlating with the engineering log description. Two atterberg limits were also undertaken in BH307 where a cohesive bed was recorded towards the base of the unit between c. 14 – 16m bgl. These recorded plasticity indices of 9 and 23 respectively, similar to the results from TP204.

The consistency index ranged between three samples ranged between 1.22 – 2.54, suggesting the samples are very stiff with moisture content below the plastic limit indicating the material is moisture deficient. This broadly correlates with the range of inferred consistency from the engineering log.

Thirty-one particle size distribution tests were undertaken within the Lowestoft Formation (Sand and Gravel), presented in Figure 5.26. The majority of tests indicate the material to be a slightly gravelly to gravelly slightly to silty/clayey sand and correlate with the engineering log descriptions. The percentage of fines in the material is shown to vary, with the material locally being encountered as either slightly gravelly sandy silt or clay, with these tests shown in a different colour on the plot. Two curves shown as dashed lines were recorded in BH203 in the central area of the site, or close to the boundary to the overlying Diamicton in BH309 which may help explain these results.

Figure 5.26: Lowestoft Formation – Sand and Gravel – Particle size distribution testing



5.6.2.2 In-situ testing - SPTs

Thirty-seven SPT tests were undertaken with the Sand and Gravel. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 5.2.2. Results have been extrapolated in accordance with CIRIA R143 (1995).

Results are presented in Table 5.12 and Figure 5.27. The tests undertaken at Snape Road record an increase in the SPT N value with depth, ranging between 14 – 57.7. This indicates the material is medium dense becoming very dense with depth in accordance with BS 5930:2015(+A1:2020). At the Converter Station, SPT N_{60} ranges between 6.5 to 267.9, and is shown to increase with depth. The two results recording N_{60} of 267.9 appear significantly greater than the remainder of testing and it is recommended these are treated with caution, no further details on the engineering log are available to help explain these results. The range of values broadly correlate with tests undertaken as part of the SPR investigation in 2021.

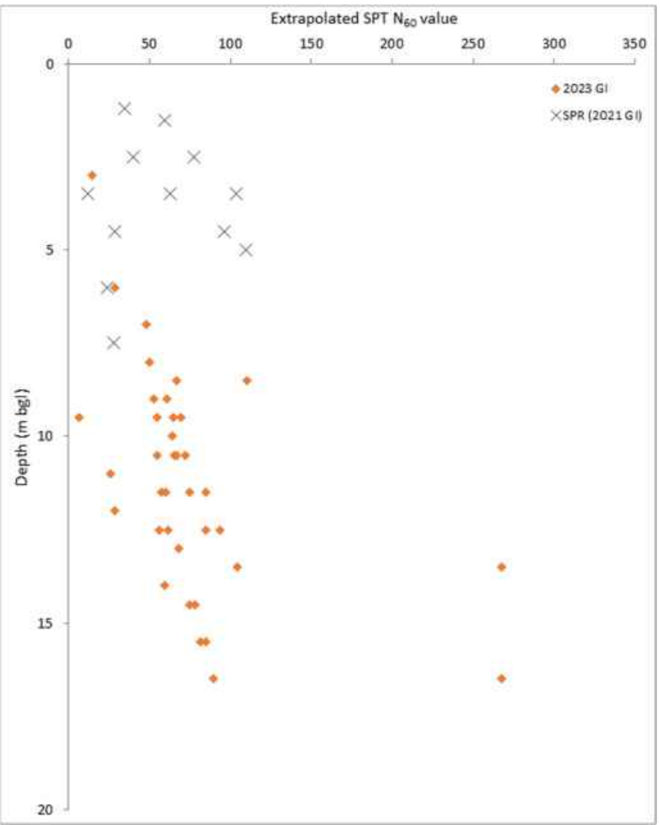
In addition, one test was undertaken in a cohesive bed recorded at the base of the glacial sequence in BH 307 at 14.5m bgl, which recorded an SPT N value of 41, correlating with the testing in granular units. This could suggest localised variability at depth, as this unit was not recorded in any of the nearby deeper boreholes.

Table 5.12: Lowestoft Formation (Sand and Gravel) – SPT testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Snape Road	Extrapolated SPT N value	5	14.0	57.7	38.5	46.0
	Extrapolated SPT N_{60} value	5	14.7	60.6	40.5	48.3

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Converter Station	Extrapolated SPT N value	32	5.2	214.3	65.3	57.1
	Extrapolated SPT N_{60} value	32	6.5	267.9	79.9	67.7
2021 SPR GI	Extrapolated SPT N_{60} value	12	11.9	109.7	56.4	49.8

Figure 5.27: Lowestoft Formation (Sand and Gravel) – SPT N_{60} value versus depth



5.6.2.3 Earthworks

A series of earthworks relationship tests were undertaken in accordance with BS 1377-2 (2022), including compaction tests utilising a 2.5kg compactive effort with an assumed particle density of 2.65 Mg/m^3, laboratory California Bearing Ratio (CBR) and Moisture Condition Value (MCV) tests (one test only, majority of material was not suitable to undertake MCV). The CBR and MCV tests were generally undertaken at the same moisture content as the corresponding compaction test to investigate the relationships between these properties.

Testing presented in this section covers the Lowestoft Formation Sand and Gravel where encountered as a distinct unit within trial pit locations, and does not assess where it was encountered as thin beds within the wider Diamicton sequence.

It should be noted that in several instances samples were combined over the strata depth to provide sufficient sampling material for the required laboratory testing. It is not thought that this is likely to have a significant impact on the test results presented based on the engineering descriptions of the material, and could potentially reflect conditions during construction dependent on the required depth of cut and fill.

A summary of the testing undertaken is presented in Table 6.14 and Figure 6.29, and is described in more detail below. It should be noted that for the purpose of Table 6.14 the full range of results of CBR and MCV tests are reported over the compaction relationship, hence a large variation in the test results is observed.

Table 5.13: Lowestoft Formation (Sand and Gravel) – Earthworks classification testing summary

Compaction

Test type	No. of tests	Maximum Dry Density (Mg/m³)			Optimum Moisture Content (%)		
		Minimum	Maximum	Average	Minimum	Maximum	Average
Light compaction (2.5kg rammer)	11	1.67	2.05	1.85	5.4	13.0	10.1

California Bearing Ratio

Test type	No. of tests	Minimum	Maximum	Average	Median	Remarks
Laboratory CBR relationship test	11 (sets of tests)	0.60	47.0	12.9	10.0	-

Moisture Condition Value

Test type	No. of tests	Minimum	Maximum	Average	Median	Remarks
Laboratory MCV test	1 (set of tests)	5.6	17.1	11.6	12.0	Undertaken in materials suitable for MCV testing only (cohesive)

The relationship testing presented in Figure 5.28 shows a reasonable variation in the composition of the Sand and Gravel across the site. The variability in the compaction curves suggests the material could vary between two main material types from an earthworks / re-use perspective, referred to as Type 1 and 2 below for simplicity:

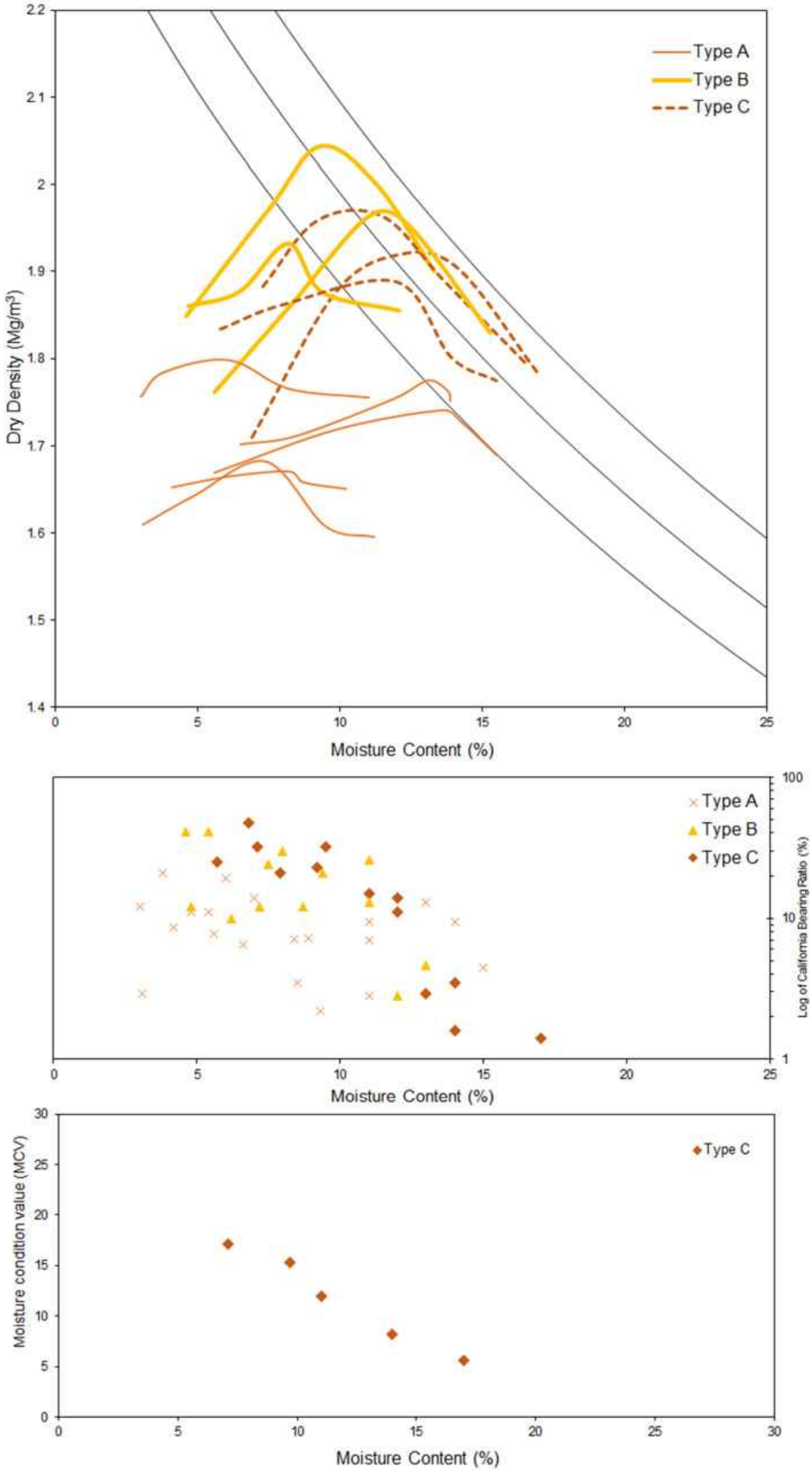
- Type A:
  - A slightly silty or clayey slightly gravelly sand which is uniformly graded. These generally struggle to achieve higher compaction (and consequently maximum dry density) due to void spaces associated with the particle grading. Tests in this material were generally encountered in the western and eastern ends of the site in most instances (e.g. including but not limited to TP221, TP513, TP222A)
  - Uniformity coefficients ranging generally between 1.8 – 2.9 from the five compaction tests suggesting the unit is uniformly graded.
- Type B:
  - Granular material which contains a greater gravel content – e.g. gravelly to very gravelly (and a minor element of fines). These are more well graded and can achieve higher compaction and maximum dry density. Several of the tests in this material were

encountered in the central area of the site in vicinity of Snape Road (e.g. including but not limited to TP404, TP511), suggesting a potential spatial relationship.
  - From three compaction tests, two uniformity coefficients were recorded as 4.3 and 10, and it was not possible to record in the remaining test due to the content of fines. These suggest this material is more well graded than Type A.
- Type C:
  - Material containing a greater fines content – e.g. sandy silty clays, slightly gravelly sandy silts or slightly gravelly very clayey sand. These are more well graded and can achieve higher compaction and maximum dry density. Some tests undertaken in vicinity of Snape Road e.g. TP204, TP218.
  - Out of three tests, one uniformity coefficient of 17 was recorded. It was not possible to measure in the remaining two tests due to the fines content, indicating the material is more well graded than Type A.

The CBR testing broadly suggests a decrease in CBR value with increasing moisture content as expected. Over the approximate range of optimum moisture content (5.4 – 13%), CBR varies between c. 2.2 – 49%. Due to lower optimum moisture contents associated with the Type 1 material, the CBR values tend to reduce at lower moisture contents in comparison to the Type 2 material discussed above. The lowest CBRs recorded are associated with the cohesive material beyond its optimum moisture content, where CBR’s of >2% are recorded meaning the material would be untrafficable and prove difficult to compact without treatment such as drying.

Only one set of MCV tests were undertaken on the cohesive material which was recorded in TP218 as a sandy silt (Type C). Around the materials optimum moisture content an MCV value of between 8.2 – 12 is recorded.

Figure 5.28: Lowestoft Formation (Sand and Gravel) – Earthworks relationship testing



5.6.2.4 Shear box testing

A series of laboratory small shear box tests were undertaken in the Lowestoft Formation (Sand and Gravel) to determine effective stress properties. These were undertaken on bulk disturbed samples, with the tests undertaken summarised in Table 5.14 below.

Table 5.14: Lowestoft Formation (Sand and Gravel) – Shear box testing summary

Hole ID	Depth (m bgl)	Normal stress – σ (kPa)	Peak angle of friction – θ (º)	Cohesion intercept, c' (kPa)
BH203	2.0	20, 40, 80	35.0	1
BH203	7.0	70, 140, 280	35.5	14
BH306	14.5	145, 290, 580	28.0	46
BH307	9.5	95, 190, 380	33.5	17
BH308	10.5	105, 210, 420	36.5	19
BH308	15.5	155, 310, 620	34.0	10
BH308	19.5	195, 390, 780	35.5	21
BH308	23.5	235, 470, 940	35.5	15
BH309	9.5	95, 190, 380	36.0	14
BH309	13.5	135, 270, 540	35.0	11
BH309	16.5	165, 330, 660	31.5	29
BH310	10.0	100, 200, 400	31.5	17
BH310	14.0	140, 280, 560	31.5	23

The reported peak angle of friction ranges between 28 – 36.5 degrees, with most testing broadly correlating with expected ranges of peak angle of friction of c. 32 – 38 estimated for uniform to well graded fine to coarse sands at similar relative density to the material encountered on site (Barnes, 2016). It is recommended that the reported cohesions are treated with caution as this material is not anticipated to have significant cohesion, and this could be a function of curve-fitting to the shear box test data.

5.6.3 Lowestoft Formation - In-situ testing – DCP testing

The Lowestoft Formation (either Diamicton and/or Sand and Gravel) were interpreted to be encountered in all DCP tests undertaken at the site adjacent to trial pits, with the Crag Group locally encountered where indicated below.

CD 225 Design for new pavement foundations (formerly the Highways Interim Advice Note 73/06) and the Transport and Road Research Laboratory (TRRL) Laboratory Report 1132 (The Structural Design of Bituminous Roads) has been used to derive California Bearing Ratio (CBR) values obtained from DCP testing using the equation below:

Log_{10} (CBR) = 2.48−1.057×Log_{10}(mm/blow)

The DCP tests have been reviewed with respect to the likely geological strata present across the wider site, with a summary below of where these units may be present. As DCP tests were only undertaken adjacent to trial pits, these were not undertaken within all strata encountered across the site as summarised in in previous sections and Appendix A / B.

5.6.3.1 Converter Station and cable route

Converter Station

- In-situ DCP testing undertaken at the Converter Station is presented in Figure 5.29. The vast majority of material encountered was cohesive, with one granular bed encountered in the Diamicton. The results indicate a lower bound CBR of c. 1% at the top of the unit with a general trend of increasing CBR with depth. Localised increases in CBR appear to correlate with more granular material and spikes in the data are likely to be attributed to presence of gravel as suggested on the engineering logs. Lower-bound results suggest that CBR increases from c. 1.0% at approximately 0.4m bgl to c. 15% at 2m bgl, with the exception of a few localised softer spots.
- The conservative long-term equilibrium CBR has also been determined based on CD 225 and LR1132, engineering log descriptions, PSD test results and plasticity testing. In the uppermost metre of the deposit, plasticity was shown to be greater (see Section 6.6.1) and an estimated value of 45 has been used for this assessment to remain conservative. LR1132 suggests that for material with a plasticity index of 45, assuming groundwater is deep that a CBR of approximately 3% should be achievable.
- It is recommended that in-situ DCP results are treated with caution as it is likely the material at the Converter Station will be reworked as part of project earthworks, which is likely to modify the material from its current state during construction.

Cable Route

- DCP testing undertaken along the cable route from the 2023 GI is presented in Figure 5.30. The majority of testing was undertaken within granular material, reflecting the presence of the Lowestoft Formation (Sand and Gravel) across much of the area where exploratory holes were undertaken. The results generally indicate a lower bound CBR of approximately 5% with localised variations with depth. CBR in most tests appears to loosely decrease from c. 10% to 5% between 0.25 to approximately 1m bgl, below which CBR broadly increases again. However, in some locations CBR remains closer to 5% throughout the test depth (e.g. TP221). A number of tests also record large sections at depth where CBR is greater than 20% and in some instances >60-80%, typically below c. 1m bgl. This could be due to the material being denser, or the presence of more gravelly material which broadly correlates with the engineering logs in some locations.
- The conservative long-term equilibrium CBR has also been determined based on CD 225 and LR1132, engineering log descriptions and PSD test results / atterberg limit testing. LR1132 suggests that for uniformly graded sands that a CBR of 20% may be achievable, which appears to be greater than the results of nearer surface in-situ testing over the likely depth of any pavements. It is recommended that any diamicton encountered is treated as described for the Converter Station above based on its plasticity index, where a long-term CBR of 3% is likely to be achievable.

Figure 5.29: DCP testing – Converter Station

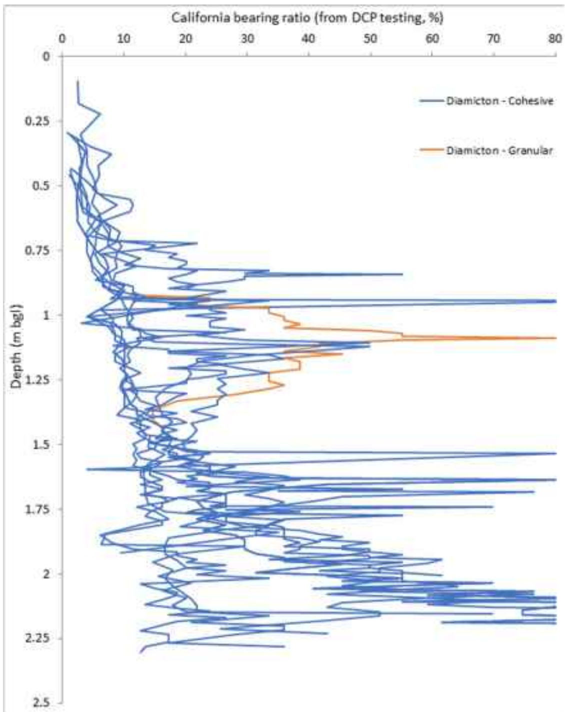
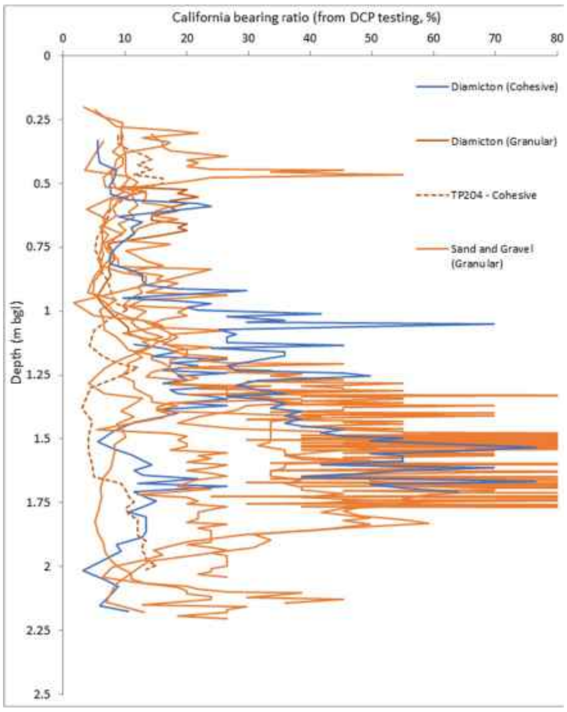


Figure 5.30: DCP testing – Cable route



5.6.3.2 Access roads, Temporary construction compounds

Access roads

- In-situ DCP testing was undertaken along the access road to the Converter Station as part of the 2023 GI, with results presented in Figure 5.31. The road traverses several different geological strata from its crossing of the River Fromus valley. However, testing was only undertaken within the Lowestoft Formation (no testing within Alluvium and Crag Group). These recorded both granular and cohesive materials, including granular beds present at the top of the Diamicton in TP525.
- In the granular materials, lower bound CBRs of approximately 5 – 10% with localised soft spots down to c. 3 – 4% are recorded. CBR also locally increases in several tests up to approximately 20 – 60% which may suggest the presence of denser material or an increase in the coarse granular content (e.g. correlating with the engineering logs where cobbles of flint are present).
- In the cohesive materials, the lower bound CBR at the top of the unit is between approximately 3 – 4%, gently increasing with depth to approximately 12 – 15%. Variations in the CBR with depth are recorded, where CBR rises to c. 20 – 30% over short depth ranges and this appears to correlate with changes in the granular content of the unit or obstructions encountered during the tests.
- The conservative long-term equilibrium CBR has also been determined based on CD 225 and LR1132, engineering log descriptions and PSD test results / atterberg limit testing. LR1132 suggests that for the Diamicton, based on plasticity testing that a long-term CBR of 3% could be achievable (see Converter Station above), and for the granular materials a long-term estimated CBR of 20% may be appropriate. However, this appears to be greater than recorded from several of the in-situ tests.

Temporary construction compounds

- DCP testing undertaken at the temporary construction compounds is presented in Figure 5.32. The compound locations are shown in Appendix B.
- In TP406 (construction compound near the Converter Station), CBR is shown to be <1% at the top of the unit and gently increases with depth to approximately 20% at 2m bgl suggesting the presence of softer material near surface.
- In TP404, a CBR of c. 10 – 15% is observed between c. 0.30 to 0.80m bgl, and CBR rapidly increases below this to c. 50 – 60%. This correlates with a unit boundary on the log, where a greater gravel content and cobbles are recorded in the sand below 0.80m bgl.
- As discussed above, similar long-term equilibrium CBR values are calculated based on LR1132 including 3% for the Diamicton and 20% for the granular materials. These broadly correlate with the results observed in these locations, though should be assessed in detail to inform relevant CBR values for design.

Figure 5.31: DCP testing – Converter Station access road

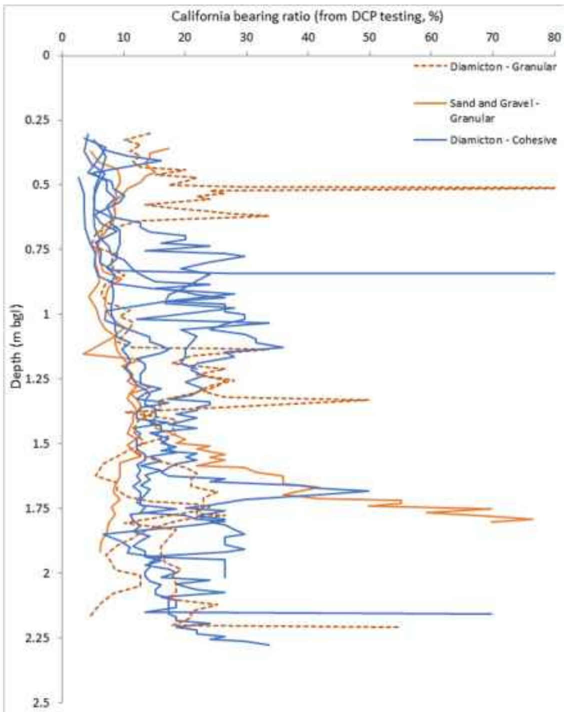
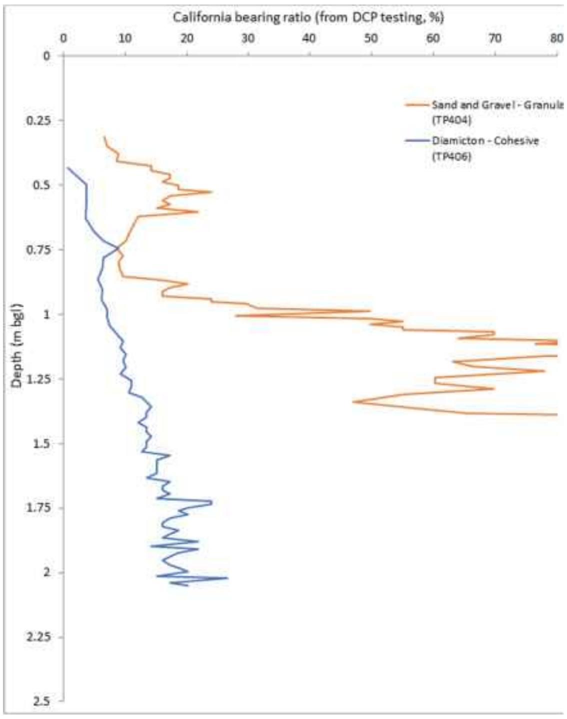


Figure 5.32: DCP testing – Temporary construction compounds (Converter station and Blackheath)



5.7 Crag Formation (Sand)

The Crag Formation forms the dominant bedrock beneath the superficial deposits across the site. It was recorded in the 2023 GI from the valley of the River Fromus at the western extent of the site, and generally at depth across the remainder of the site, overlain by the Lowestoft Formation (Sand and Gravel).

It should be noted that due to similar engineering description and laboratory test results, it is difficult in some instances to discern between the overlying Lowestoft Formation (Sand and Gravel) and the Crag Group, therefore this should be treated with caution.

The Crag group was encountered as a dense to very dense orangish brown to dark grey slightly to gravelly clayey or silty SAND with rare to occasional shell fragments, flasers of dark grey clay or soft silty nodules. It was locally recorded as very stiff thinly laminated dark grey sandy silty CLAY in BH309 at the base of the borehole, and was potentially locally cemented in BH310 where fragments of iron stained sandstone were recorded on the engineering log (this may represent a cemented bed).

Localised variations in the unit were recorded across the wider site, including the following:

- In proximity to the River Fromus at the western end of the site, it was recorded as a dense slightly sandy gravel at its top.
- At the eastern end of the cable route, it's possible the Chillesford Church Clay Member was encountered from 3.8m bgl in TP222A, and was described as a stiff friable thinly laminated slightly sandy silty clay with occasional iron staining.

5.7.1 Soil classification testing

Limited classification testing was undertaken in the Crag Group, and is summarised below.

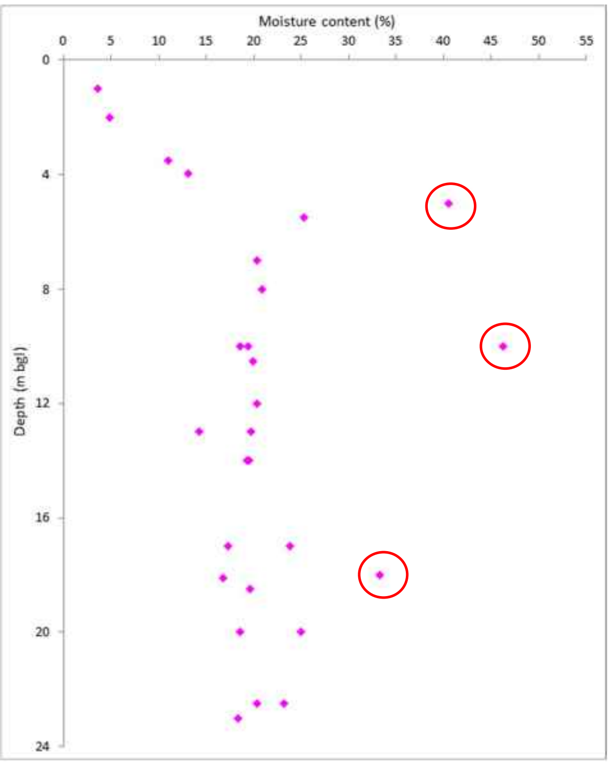
Table 5.15: Crag Group – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content	29	3.6	46.2	20.5	19.6
Bulk density (Mg/m^3)	2	2.04	2.31	2.18	2.18
Dry density (Mg/m^3)	2	1.64	2.04	1.84	1.84

Two bulk density tests were undertaken on undisturbed samples, collected in material which suggested borderline cohesive behaviour. These recorded bulk densities of between 2.04 – 2.31 Mg/m^3. These broadly correlate with the expected range of weight density based on the relatively density of the material, which is discussed in Section 5.7.2.

A series of moisture content tests were undertaken on disturbed samples, presented in Figure 5.33 with respect to metres below ground level (trends in the data were more apparent in m bgl as opposed to m AOD). Many of these were tested below the groundwater table, and/or water was added to assist drilling, therefore it is recommended these are treated with caution (including elevated water contents circled in red in Figure 5.33), as these results are unlikely to representative of natural conditions. Moisture content is shown to increase with depth near-surface, and remains fairly consistent from approximately 8m bgl, with the majority of tests recording moisture contents between approximately 15 – 25%.

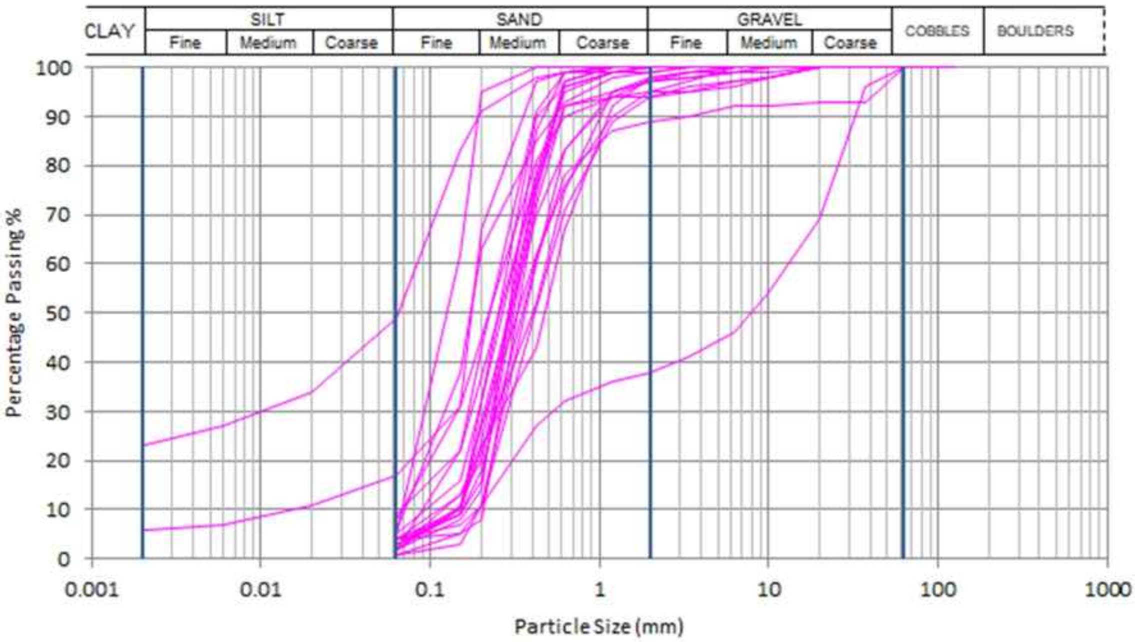
Figure 5.33: Crag Group – Moisture content versus depth



Twenty four particle size distribution tests were undertaken within the Crag Group, presented in Figure 5.34.

The vast majority of tests indicate the material to be a slightly gravelly slightly silty sand which is generally uniformly graded and correlates with the engineering log descriptions. A few tests record slight variations, including a very sandy gravel at the top of the unit in BH501 near the River Fromus, and a much greater percentage of fines being recorded in BH307 at 18m bgl which also correlate with the engineering logs in these locations. When comparing the particle size curves to the Lowestoft Formation (Sand and Gravel) they are in most cases fairly similar, though a greater gravel and/or fines content is generally observed in the Lowestoft Formation (Sand and Gravel). As mentioned above, due to difficulties in discerning the boundary between these two units these results should be treated with caution.

Figure 5.34: Crag Group – Particle size distribution testing



5.7.2 In-situ testing – SPTs

Eighty six SPT tests were undertaken with the Crag Group. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 5.2.2. Results have been extrapolated in accordance with CIRIA R143 (1995).

Results are presented in Table 5.16 and Figure 5.36, including tests undertaken as part of the 2021 SPR GI for comparison.

A wider trend across the district appears to suggest decreasing SPT N values with level, observed to approximately 0m AOD. Below 0m AOD, SPT N values loosely begin to increase again. Its is possible this could relate to weathering or changes in composition of the unit, though there is no distinct changes observed on the engineering logs to help correlate with this. At the top of the deposit where the Crag was recorded at the River Fromus, the SPT N values are lower indicating the unit is locally loose but generally medium dense to dense in accordance with BS 5930:2015(+A1:2020).

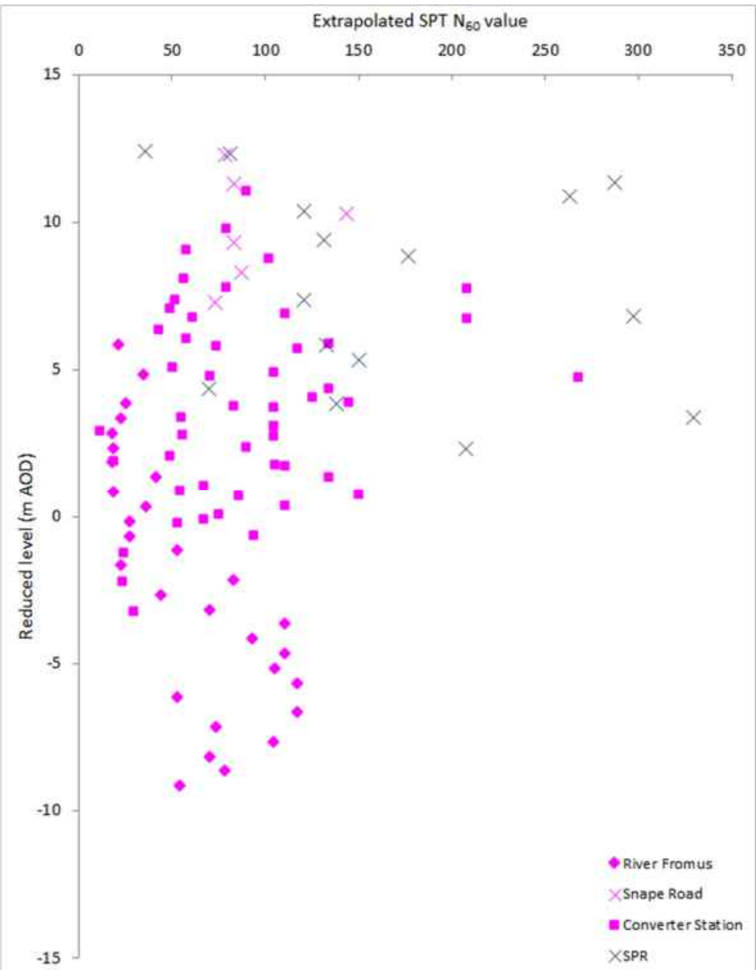
In terms of m bgl (not presented graphically), with depth below c. 10m bgl, all SPT N values are greater than 50 indicating it is very dense, except for a few localised areas at the Converter Station in BH308 and BH310 where N_{60} values locally drop at depth to c. 11.3 – 29.4, suggesting the Crag is locally medium dense, correlating with the trends observed over this depth range (c. 3m to -3m AOD). No distinct features are recorded on the engineering logs which may help explain these results.

Table 5.16: Crag Group – SPT testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Snape Road	Extrapolated SPT N value	6	69.8	136.4	87.1	78.9

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
	Extrapolated SPT N_{60} value	6	73.3	143.2	91.4	82.9
Converter Station	Extrapolated SPT N value	50	9	300	78.2	71.4
	Extrapolated SPT N_{60} value	50	11.3	375	94.0	80.8
River Fromus	Extrapolated SPT N value	29	15.0	100.0	50.2	50.0
	Extrapolated SPT N_{60} value	29	17.9	117.2	57.4	52.5
2021 SPR GI	Extrapolated SPT N_{60} value	20	35.6	493.8	225.7	176.7

Figure 5.35: Crag Group – SPT N_{60} value versus depth



5.7.3 Shear box testing

A series of laboratory small shear box tests were undertaken in the Crag Group to determine effective stress properties. These were undertaken on bulk disturbed samples, with the tests undertaken summarised in Table 6.19 below.

Table 5.17: Crag Group – Shear box testing summary

Hole ID	Depth (m bgl)	Normal stress – σ (kPa)	Peak angle of friction – θ (º)	Cohesion intercept, c' (kPa)
F22-BH203	10.0	100,200,400	35.5	16
F22-BH203	13.0	130,260,520	36.5	0
F22-BH306	21.5	215,430,860	36.5	0
F22-BH307	17.5	175,350,700	34.0	0
F22-BH307	21.5	215,430,860	37.0	12
F22-BH309	19.5	195,390,780	36.5	14
F22-BH309	22.5	225,450,900	33.0	31
F22-BH310	18.0	180,370,720	33.5	32
F22-BH501	5.0	35,70,140	35.5	12
F22-BH501	9.0	55,110,220	33.5	5
F22-BH501	15.0	65,130,260	37.5	12
F22-BH502A	4.5	33,65,130	31.5	15
F22-BH502A	6.5	43,85,170	35.5	6
F22-BH502A	10.5	63,125,250	36.1	6
F22-BH502A	14.5	83,165,330	31.5	26

The reported peak angle of friction ranges between 31.5 – 37.5 degrees, with most testing broadly correlating with expected ranges of peak angle of friction of c. 32 – 38 estimated for uniform to well graded fine to coarse sands at similar relative density to the material encountered on site (Barnes, 2016). It is recommended that the reported cohesions are treated with caution as this material is not anticipated to have significant cohesion, and this could be a function of curve-fitting to the shear box test data

5.8 Coralline Crag Formation

The Coralline Crag Formation was encountered in vicinity of the Red Penguin HDD alignment. The top depth of the unit varied between 0.35 to 9.5m bgl (4.27 to -6.8m AOD), with the depth the unit was encountered at increasing towards the coast (eastwards). Its thickness also thinned slightly eastwards, and varied between approximately 15.2 – 20.15m in thickness.

The unit was encountered as a medium to very dense orange or orangish brown becoming light/dark grey with depth slightly clayey gravelly fine to coarse SAND with occasional to frequent shell fragments. The gravel was composed of fine to coarse cemented sand and occasional cemented shells which have been disturbed during sampling recovery. A photograph from site observations of the recovered cemented fragments is shown below for information in Figure 5.36. In RedP-BH1A a local bed 0.1m thick of very stiff friable orangish brown mottled black and grey very sandy SILT was also encountered within the unit.

Figure 5.36: Shelly cemented gravel to cobble sized fragments from the Coralline Crag Formation

5.8.1 Soil classification testing

A summary of the soil classification testing undertaken in the Coralline Crag Formation is presented below.

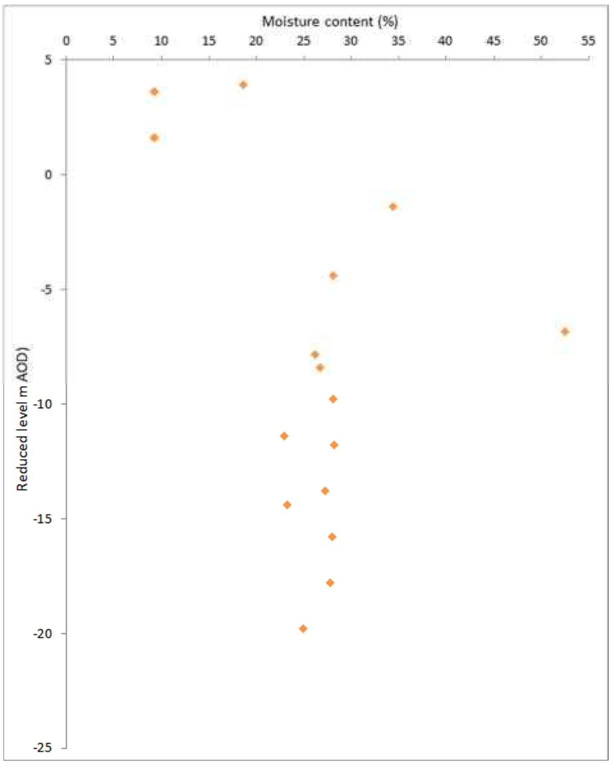
Table 5.18: Coralline Crag Formation – Summary of classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content	16	9.3	52.5	26.0	27.0

Sixteen moisture content tests were undertaken in the Coralline Crag Formation, presented in Figure 5.37. These suggest the material near-surface was generally of lower moisture content, and with depth this increased. However, water was added to assist drilling and some tests were below the groundwater table, therefore the results should be treated with caution. In addition, one test result records a much greater water content of 52.5%, it is recommended this is treated with caution as it appears erroneous in comparison to the remaining data.

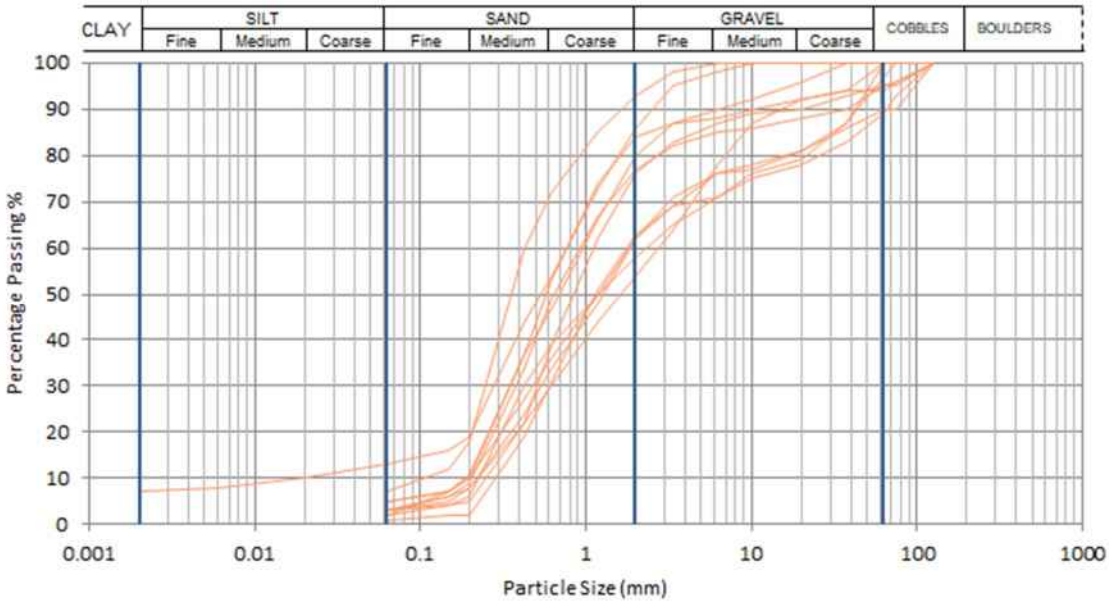
One atterberg limit test was undertaken over a 0.10m thick bed described as very stiff very sandy silt, however the test returned a non-plastic result.

Figure 5.37: Coralline Crag Formation – Moisture content versus level



A series of eleven particle size distribution tests were undertaken in the Coralline Crag Formation, presented in Figure 5.38. These generally indicate the material to be a slightly silty/clayey gravelly to very gravelly fine to coarse sand with local low cobble content, and broadly correlate with the engineering log descriptions. The gravel / cobble size fraction is likely to be attributed to cemented fragments as indicated on the engineering logs and in Figure 5.36 and is a result of disturbance during sample, therefore the test curves should be treated with caution.

Figure 5.38: Coralline Crag Formation – Particle size distribution testing



5.8.2 In-situ testing

A series of thirty-five SPTs were conducted in the Coralline Crag Formation as part of the GI. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 6.2.2. Results have been extrapolated in accordance with CIRIA R143 (1995).

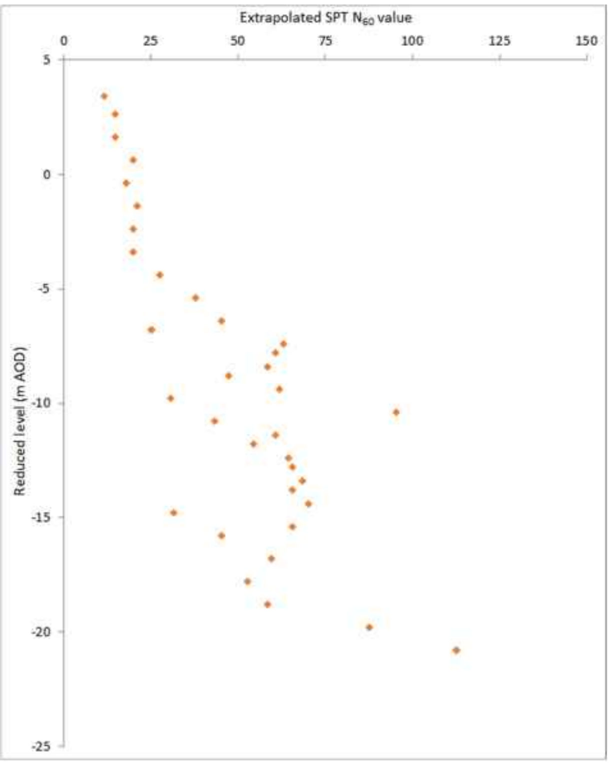
Table 6.21 summarises the results of the SPT testing for the Coralline Crag Formation, with results presented in Figure 6.40. The SPT N values are shown to increase with level, with many recording refusal (>50 blows for the test). From approximately -5m AOD an increase in SPT N value is observed and appears to correlate with a unit boundary within RedP-BH-4 where the unit is described as very gravelly (gravel comprises of cemented sand), which helps to explain the trend observed.

The tests undertaken record N values ranging between 11.0 – 107.1, indicating the material is medium dense becoming dense to very dense with level in accordance with BS 5930:2015 (+A1:2020). This is likely to be partially attributed to the cementation of the material as seen in Figure 5.39.

Table 5.19: Coralline Crag Formation – SPT testing summary

Parameter	No. of tests	Minimum	Maximum	Mean	Median
Extrapolated SPT N value	35	11.0	107.1	46.2	50.0
Extrapolated SPT N_{60} value	35	11.6	112.5	48.5	52.5

Figure 5.39: Coralline Crag Formation – SPT N_{60} value versus level



5.8.3 Shear box testing

A series of laboratory small shear box tests were undertaken in the Coralline Crag Formation to determine effective stress properties. These were undertaken on bulk disturbed samples, with the tests undertaken summarised in Table 5.20 below.

Table 5.20: Coralline Crag Formation – Shear box testing summary

Hole ID	Depth (m bgl)	Normal stress – σ (kPa)	Peak angle of friction – θ (º)	Cohesion intercept, c' (kPa)
RedP-BH-1A	7.5	50,100,200	40.5	0
RedP-BH-1A	9.5	60,120,240	39.5	26
RedP-BH-1A	12.5	75,150,300	42.5	0
RedP-BH-1A	16.5	95,190,380	42	33
RedP-BH-1A	18.5	105,210,420	44.5	20
RedP-BH-1A	22.5	125,250,500	34.5	32
RedP-BH-4	5	55,110,220	41.5	4
RedP-BH-4	9	70,140,280	43	30
RedP-BH-4	12	85,170,340	44	18
RedP-BH-4	17	85,170,340	41.5	0

The reported peak angle of friction generally ranges between 40.5 – 44.5 degrees, with one test recording 34.5 degrees. This broadly suggests a greater range of peak angle of friction indicated for granular materials at similar relative density to the material encountered on site (Barnes, 2016). It is likely that particle angularity from shell fragments and cementation (which has been disturbed during sampling) will elevate the angle of friction and this may be responsible for some of the results observed.

It is recommended that the reported cohesions are treated with caution as this material is not anticipated to have significant cohesion, and this could be a function of curve-fitting to the shear box test data.

5.9 Thames Group (London Clay Formation)

The London Clay Formation was encountered at the site beneath the River Fromus crossing south of Saxmundham, as well as the Red Penguin HDD alignment north of Aldeburgh. This unit was found to underlie the Crag Group/ Coralline Crag Formation respectively

It was described as a firm becoming stiff to very stiff closely to very closely fissured dark grey CLAY to sandy clayey SILT, which was locally gravelly at its top, encountered from depths ranging between 17.5 – 18.2m bgl near Saxmundham (c. -9.6 to -10.4m AOD), and 20.50 – 24.70m bgl at the Red Penguin HDD site adjacent to the coast (c. -15.9 to -22m AOD) suggesting potentially a very gentle apparent dip to the east which correlates with wider structural trends shown on the BGS 1:50,000 mapping.

5.9.1 Soil classification testing

A summary of the soil classification testing undertaken within the London Clay Formation is presented below. For production of selected figures, the data from Saxmundham and Aldeburgh have been segregated due to their distance apart and based on the trends observed between the two areas. It is possible that different sub-units of the London Clay Formation are encountered, or there is variation in its depositional environment between Saxmundham and Aldeburgh based on the engineering properties and distance apart.

Table 5.21: London Clay Formation – Soil classification testing

Parameter	No. of tests	Minimum	Maximum	Average	Median
Moisture content (%)	25	27.5	50.3	35.8	32.9
Plastic limit (%)	15	18	42	29.7	30
Liquid limit (%)	15	42	98	62.6	62
Plasticity index (%)	15	13	56	32.9	34
Consistency Index	15	0.10	1.18	0.80	0.87
Bulk density (Mg/m^3)	10	1.75	1.99	1.88	1.87
Dry density (Mg/m^3)	10	1.17	1.53	1.37	1.36

A series of ten bulk / dry density tests were undertaken on undisturbed samples, presented in Figure 5.40. The tests record bulk density ranging between 1.75 - 1.99 $Mg/m^{3.}$ Density appears to show no distinct trend at the Red Penguin locations, though a loose increase with depth is observed at Saxmundham. The range of bulk density for the London Clay suggests a medium to high strength clay in accordance with BS 8004:2015, which correlates with engineering log descriptions of the material.

Moisture content testing undertaken in the London Clay is presented in Figure 5.41. At Saxmundham, moisture content is shown to loosely decrease with level, however no change in trend is observed with level at the Red Penguin area.

Liquid limit, plastic limit and moisture content testing is presented in Figure 5.42, and plasticity index testing in Figure 5.43. For tests undertaken at Saxmundham, the majority of moisture contents sit either close to or below the plastic limit suggesting moisture deficiency, and a few samples sit close to the centre of the plastic and liquid limits. Plasticity index is shown to range between 28 – 44 for these samples.

Samples at Red Penguin appear to be slightly more variable, with moisture content sitting closer to the plastic limit from below the top c. 5m of the deposit, and the unit appears to be more softened at its top (see consistency index results discussed below). There also appears to be distinct variations in plasticity index with depth:

- Between approximately -17 to -19m AOD plasticity index is 23 – 24
- Between 19m AOD to 27m AOD, plasticity index appears to loosely decrease with depth from a maximum of 56, reducing to 14 based on the tests undertaken which could potentially relate to a depositional sequence within the unit.

Figure 5.40: London Clay Formation – Density versus level

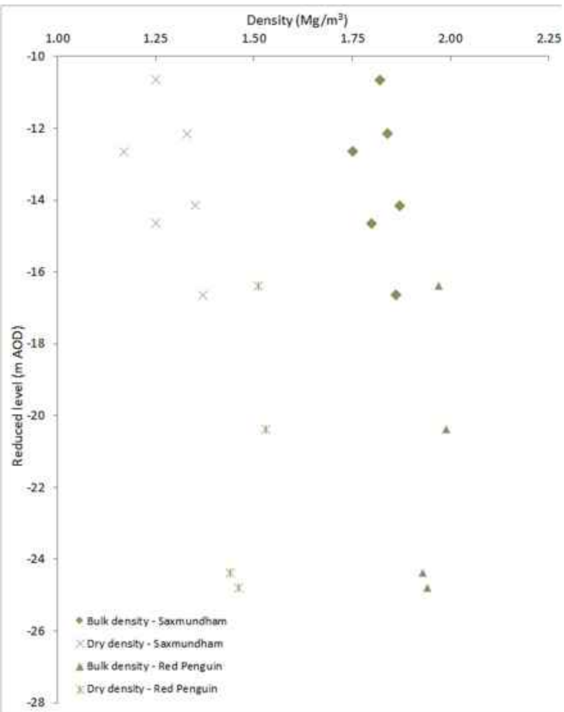


Figure 5.41: London Clay Formation – Moisture content versus level

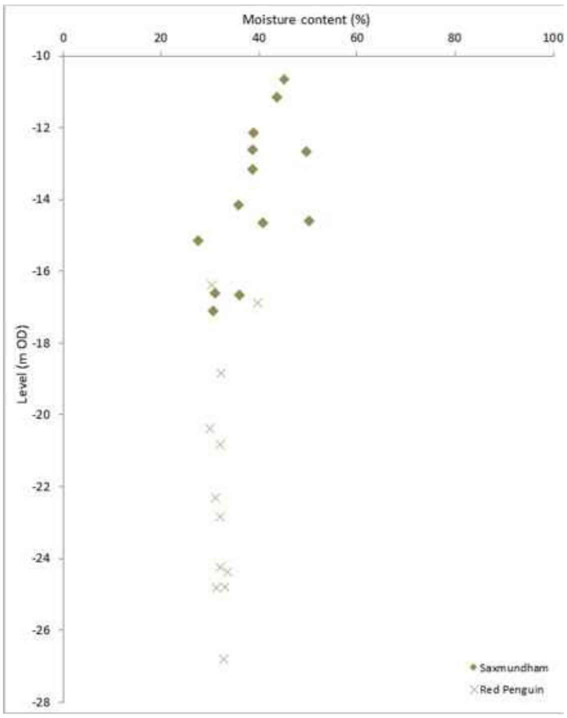


Figure 5.42: London Clay Formation – Liquid limit, plastic limit and moisture content versus level

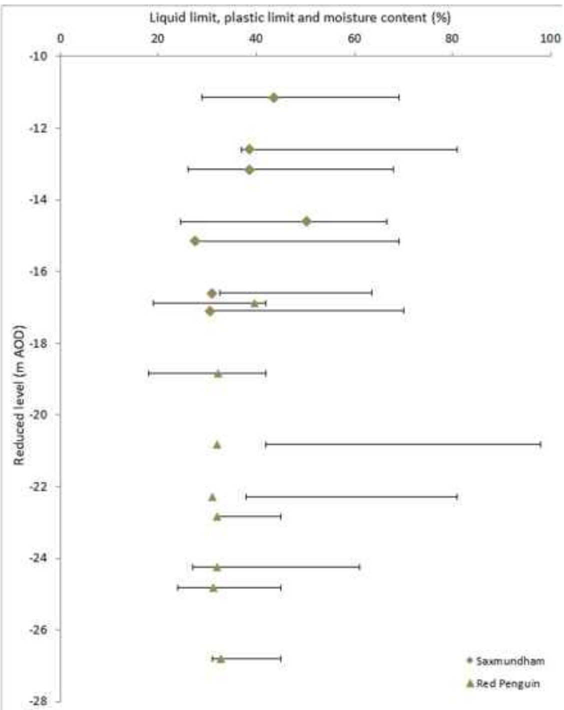
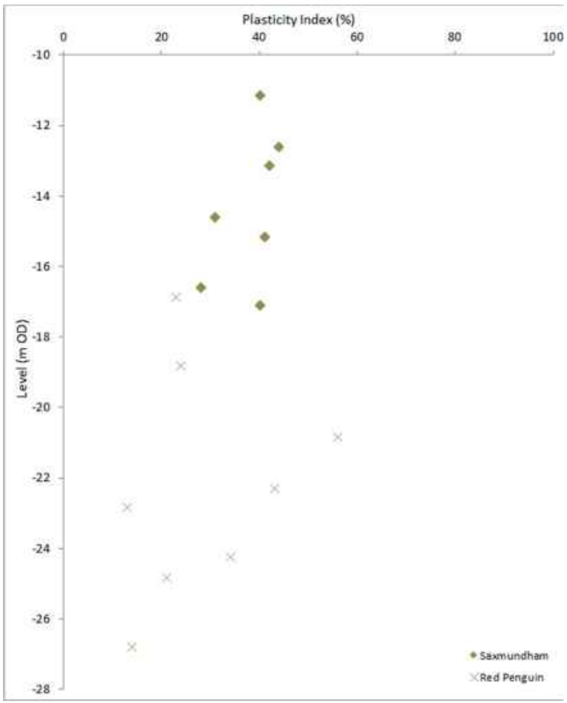


Figure 5.43: London Clay Formation – Plasticity index versus level



Consistency index has been derived for the London Clay Formation (as per guidance in BS EN ISO 14688-2:2004 + A1:2013, see Section 6.2.1). and is presented versus level in Figure 5.44. The consistency index ranges between 0.10 – 1.18, with the trends across the site discussed below.

- At Saxmundham, consistency has a loose increase between c. -11 to -17m AOD. One sample (circled in red) appears softer than the remaining material, though limited information is noted on the engineering logs and laboratory information to determine the cause of this and it should be treated with caution.
- At Red Penguin, consistency is much lower between c. -17 to -19m AOD, where the material is recorded as very soft to soft. This contradicts the engineering log descriptions which describe the material as stiff, therefore it is recommended that these results are treated with caution. Consistency appears to loosely decrease with depth from very stiff becoming firm between c. -21 to -27m AOD, which correlates with observations in moisture content and plasticity.

Figure 5.44: London Clay Formation – Consistency index versus level

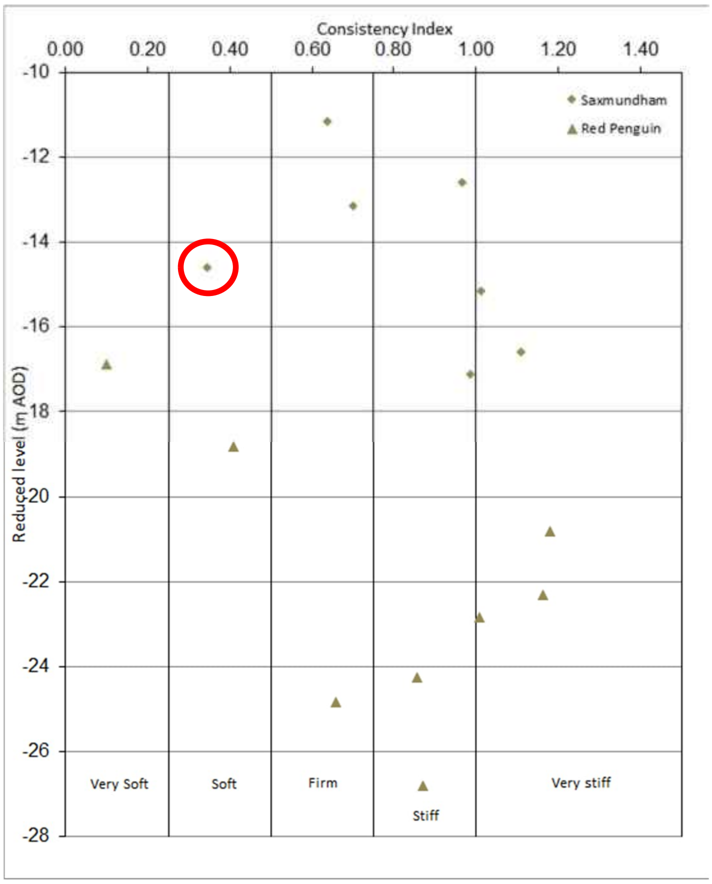
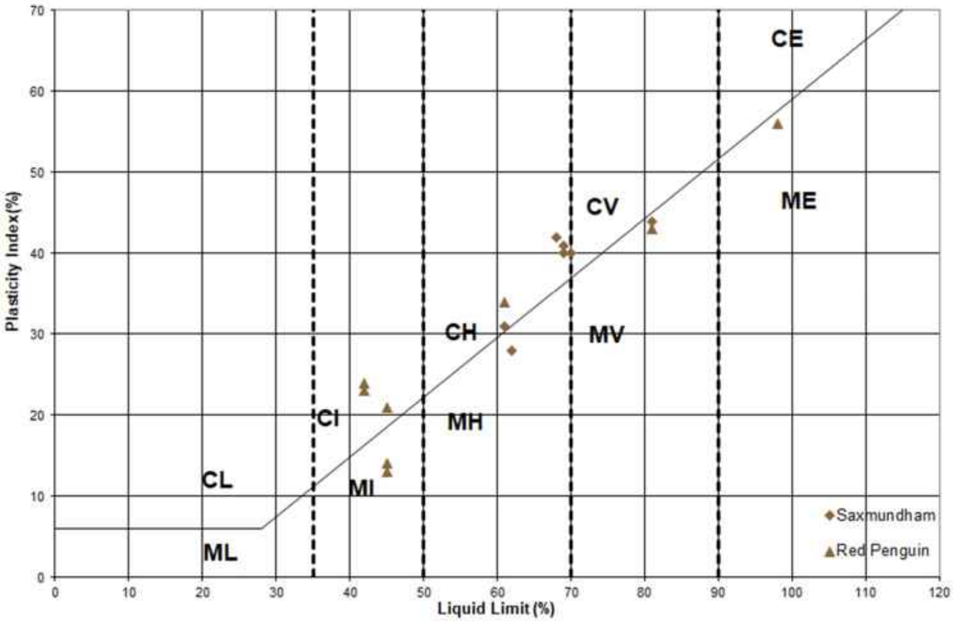


Figure 5.45 presents the A-line plot of plasticity index versus liquid limit for the London Clay Formation. This suggests the material ranges between an intermediate to extremely high plasticity, with trends observed across the site discussed below:

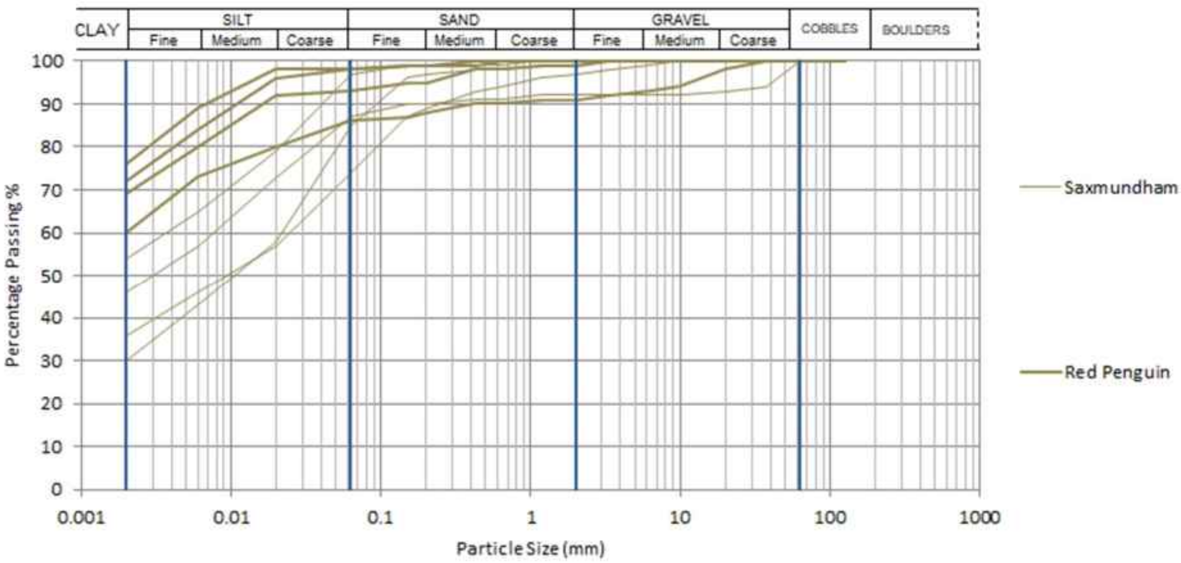
- At Saxmundham, the London Clay Formation is typically recorded as a high, bordering on very high plasticity clay and locally tending to high plasticity silt.
- At Red Penguin, the London Clay Formation appears to be more variable in its plasticity characteristics, ranging between low to high plasticity clay, and low to extremely high plasticity silt.

Figure 5.45: London Clay Formation – A-line plot of plasticity index versus liquid limit



A series of eight particle size distribution tests were undertaken in the London Clay Formation, presented in Figure 5.46. These indicate the material to be a slightly sandy slightly gravelly silty CLAY, with other soil classification testing discussed above also suggesting this may tend in its behaviour locally to clayey SILT. The tests at Saxmundham generally record a slightly greater coarser / granular content than those at the Red Penguin area.

Figure 5.46: London Clay Formation – A-line plot of plasticity index versus liquid limit



5.9.2 In-situ testing - SPTs

A series of nineteen SPTs were conducted in the London Clay Formation as part of the GI. It is stated that SPTs were conducted in accordance with BS EN ISO 22476-3: 2005(+A1:2011) and SPT Hammer Energy Test Reports were provided. Therefore, the raw N values have been converted to N_{60} values, as detailed in Section 6.2.1. Results have been extrapolated in accordance with CIRIA R143 (1995).

Table 5.22 summarises the results of the SPT testing for the London Clay Formation, with results presented in Figure 5.47. As discussed above, the data has been separated into the two areas of the site where the unit was encountered, due to differences observed between Saxmundham and Aldeburgh (e.g. potential for different sub-unit of the London Clay Formation).

At Saxmundham, the SPT values record a loose increase with level, with no changes in trend observed at the Red Penguin area of the site. The SPT values at Saxmundham were on average reasonably lower than those at the Red Penguin site as shown in Figure 5.47.

Two tests undertaken have not been considered representative and are not summarised in the below table. These include:

- One SPT test in BH502A at the top of the deposit recorded 50 blows for 35mm of penetration (equating to an extrapolated SPT N and N_{60} of 428 and 535 respectively) this could potentially relate to presence of a claystone / flint obstruction and is not included below.
- One test in BH501 at the top of the unit crossed the strata boundary from the Crag Group by approximately 50mm and records an elevated SPT N value compared to the remaining data (data point circled in red below), the presence of Crag over the test section is likely to make this result non-representative and it has not been included in Table 5.22.

The undrained shear strength of the London Clay Formation has been calculated from SPT data using the equation presented within Stroud and Butler (1978) as described in Section 5.4. A conservative f_1 value of 4.2 was taken based on the correlation between plasticity index (a conservative value of 44 is chosen for Saxmundham and 45 for Red Penguin), as presented in Stroud and Butler.

Table 5.22: London Clay Formation – SPT testing summary

Site area	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Saxmundham *	Extrapolated SPT N value	8	23.0	42.0	31.1	32.0
	Extrapolated SPT N_{60} value	8	24.2	52.5	36.3	36.9
	Undrained Shear Strength (kPa), derived from SPT N_{60} value	8	101.4	220.5	152.3	155.0
Red Penguin	Extrapolated SPT N value	9	42.0	51.7	47.2	48.0
	Extrapolated SPT N_{60} value	9	44.1	54.3	49.2	50.4
	Undrained Shear Strength (kPa), derived from SPT N_{60} value	9	185.2	228.1	166.6	211.7

*Two SPT N values are not included in the summary as they are not considered representative, discussed above.

Figure 5.47: London Clay Formation – SPT N_{60} value versus level

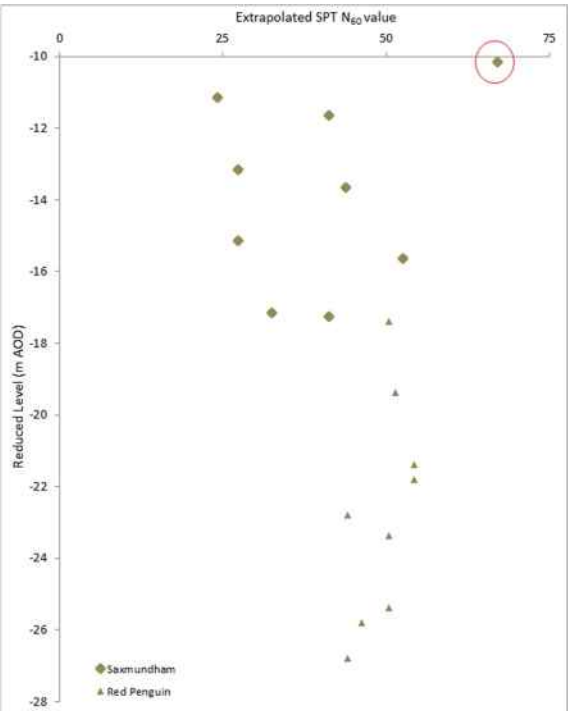
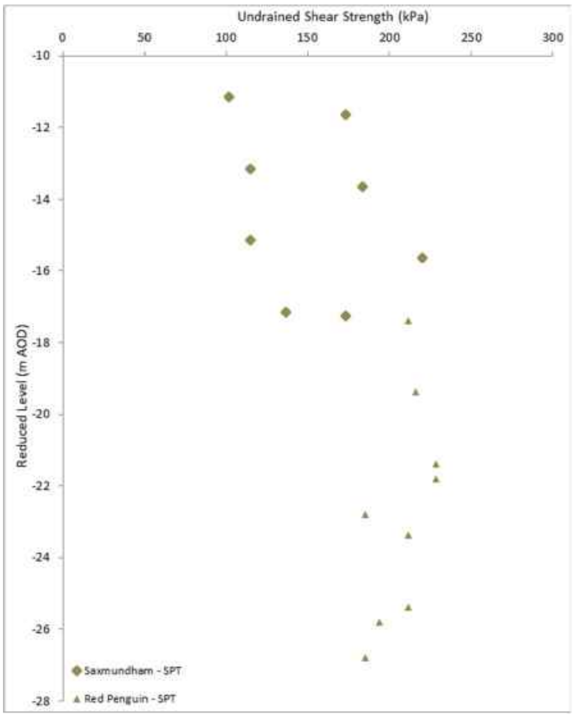


Figure 5.48: London Clay Formation – Undrained shear strength from SPT N_{60} versus level



5.9.3 Undrained shear strength testing

Direct measurement of the undrained shear strength was undertaken in the form of seven unconsolidated undrained triaxial tests and three consolidated undrained triaxial tests. These are summarised in Table 5.23 and Figure 5.49, alongside the undrained shear strength derived from SPT testing to review their relationship with depth and compare undrained shear strength derived from different methodologies.

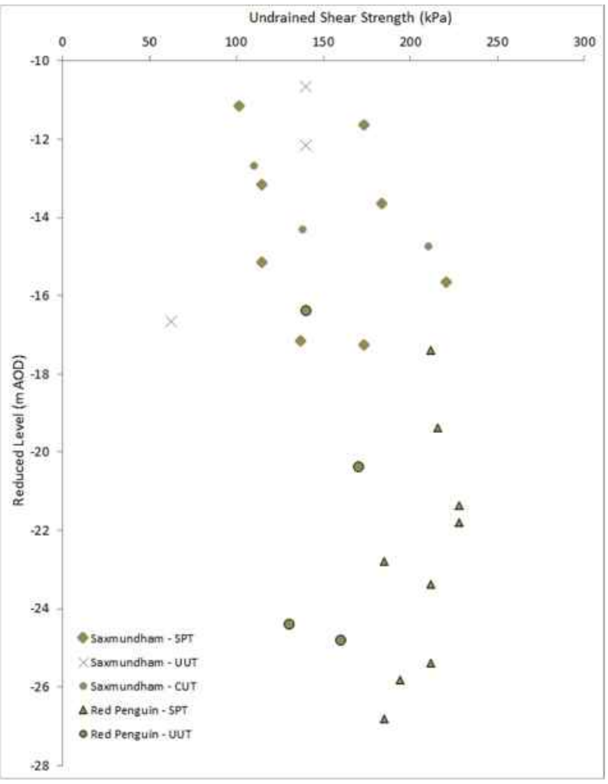
Table 5.23: London Clay Formation – Undrained shear strength testing summary

Site area	Parameter	Source	No. of tests	Minimum	Maximum	Mean	Median
Saxmundham	Undrained shear strength	UUT	3	62	140	114	140
	Undrained shear strength	CUT	3	110	211	153.0	138.0
	Undrained Shear Strength (kPa), derived from SPT N_{60} values	SPT	8	101.4	220.5	181.8	185.2
Red Penguin	Undrained shear strength	UUT	4	130	170	150	150
	Undrained Shear Strength (kPa), derived from SPT N_{60} values	SPT	9	185.2	223.1	208.0	211.7

The UUT test results suggest the material is of medium to high strength near Saxmundham, and high to very high strength at the Red Penguin area. The laboratory test results generally suggest a slightly lower undrained shear strength than inferred from the empirical correlations from in-situ SPT testing, though there is reasonable correlation between the two test methods.

One UUT test result which recorded 62kPa appears slightly lower than the remainder of testing, it is possible that this has been influenced by any potential presence of fissures or gravel in the sample, though limited information is available on the test sheet to provide further details.

Figure 5.49: London Clay Formation – Undrained shear strength (laboratory and SPT testing) versus level



Consolidated Undrained Triaxial testing

The results of drained parameters (effective angle of friction and cohesion) obtained from the consolidated undrained triaxial tests suggested angles of friction ranging between 33 – 33.7 degrees for cohesions of between 0 – 2.5kPa. It is recommended that these are treated with caution as they are thought to be unrepresentative of the materials engineering properties, which could be . This should be treated with caution due to the range of loads the samples were tested over, which may make it difficult to determine the angle of shearing resistance and cohesion with more confidence. Reference should be made to the Structural Soils factual report for full test information.

5.10 Permeability and Soakaway testing (BRE 365)

A series of borehole falling head permeability tests, and soakaway tests in trial pits were undertaken across the site. These are summarised in Table 6.26 and Table 6.27 respectively.

Where applicable, the lowest infiltration rate for each test has been presented in accordance with BRE 365 (Soakaway Design), rounded to one decimal place.

5.10.1 Borehole permeability

Borehole permeability tests undertaken are shown in Table 5.24.

Tests within the Lowestoft Formation (Diamicton) indicated a measured permeability between 2.93×10^{-6} to 1.29×10^{-5} m/s. In addition, it was not possible to calculate permeability in one test due to insufficient fall in water level. The range in permeability correlates with fine sands to silty sand mixtures based on Barnes (2016), which do not correlate with the predominant engineering log descriptions in the boreholes which record slightly sandy slightly to very gravelly clays with local medium cobble content. Occasional lenses of fine sand are recorded, which could help explain some of the results observed.. As a result it is recommended these tests are treated with caution as they may not be representative for the material.

Borehole permeability tests within the Coralline Crag Formation recorded permeabilities ranging between 1.83×10^{-5} to 1.34×10^{-7} m/s (one result being extrapolated to determine permeability), which correlates to ranges of permeability between sand/gravel mixtures or fine sands to silty sands based on Barnes (2016). This broadly correlates with the engineering log descriptions of the recovered material, though it is noted the material was disturbed due to the sampling techniques and in-situ it is cemented at depth which could influence the permeabilities.

Table 5.24: Summary of borehole permeability testing

Site area	Hole ID	Strata	Test section depth (m bgl) [m AOD]	Permeability (m/sec)	Remarks
Converter Station	BH306	Lowestoft Formation (Diamicton)	1.47 – 1.97 [23.77 – 23.27]	N/A	No drop in water level recorded in 60 minutes, therefore no calculation of infiltration possible
	BH307		2.15 – 3.0 [21.73 – 20.88]	2.93×10^{-6}	
	BH308		2.0 – 3.0 [22.41 – 21.41]	1.29×10^{-5}	
	BH309		2.0 – 3.0 [22.58 – 21.58]	9.33×10^{-6}	
Red Penguin HDD	RedP-BH-1	Coralline Crag Formation	12.0 – 13.0 [-9.3 - -10.3]	1.83×10^{-5}	
	RedP-BH-1	Coralline Crag Formation	18.0 – 19.0 [-15.3 - -16.3]	1.34×10^{-7}	Data extrapolated by Contractor to determine permeability result

5.10.2 BRE 365 soakaway testing

A summary of soakaway tests is presented in Table 5.25.

The majority of trial pit infiltration tests were undertaken within the Diamicton of the Lowestoft Formation, where insufficient falls in water level were measured to calculate a permeability after the tests were run for up to approximately 5 – 6 hours. The tests undertaken within the granular components of the Lowestoft Formation (Sand and Gravel) were able to be repeated for three full test runs in accordance with BRE 365, with the permeabilities shown to range between 1.52 – 2.34×10^{-4} m/s. This broadly correlates with the range of permeability expected for clean sands and sand-gravel mixtures as detailed in Barnes (2016) and correlates with the engineering log descriptions of the material.

Table 5.25: Summary of BRE 365 soakaway testing in trial pits

Site area	Hole ID	Strata	Test section depth (m bgl) [m AOD]	Permeability (m/sec)	Remarks
Cable route	TP204	Lowestoft Formation – Cohesive	1.30 – 2.30 [13.38 – 12.38]	N/A	Insufficient fall in water level to calculate infiltration rate
Converter Station	TP312		1.0 – 1.98 [23.40 – 21.42]		
	TP313		0.50 – 1.50 [24.48 – 23.48]		
	TP316		1.0 – 2.0 [22.74 – 21.74]		
	TP317		0.55 – 1.50 [23.24 – 22.29]		
Construction compounds	TP404 (Blackheath)	Lowestoft Formation - Granular	1.10 – 1.80 [11.96 – 11.26]	1.52×10^{-4}	Three full test runs completed in accordance with BRE 365. Permeability reducing from test 1 to 3.
	TP406 (Converter Station)	Lowestoft Formation - Cohesive	0.50 – 1.48 [20.07 – 19.09]	N/A	Insufficient fall in water level to calculate infiltration rate
Permanent access (Converter Station)	TP513	Lowestoft Formation - Granular	0.40 – 1.10 [16.97 – 16.27]	2.34×10^{-4}	Three full test runs completed in accordance with BRE 365. Permeability reducing from test 1 to 3.

In addition to the above, the 2021 SPR GI information has been reviewed for soakaway tests which may be representative for the proposed works. As part of the proposed works an infiltration basin is proposed in vicinity of the substation connection, as detailed in Section 1.2.2. The relevant test results are summarised in Table 5.26.

The material encountered within c. 100m of the proposed infiltration basin at the Friston substation was encountered in TP330B, TP013A-B and TP014C as a silty or clayey to very clayey fine to coarse SAND which was locally described as gravelly. The infiltration rates broadly correlate with the expected permeability for fine sands to silty sands as detailed in Barnes (2016).

Table 5.26: Summary of BRE 365 soakaway testing in trial pits – 2021 SPR GI

Site area	Hole ID	Strata	Test section depth (m bgl) [m AOD]	Permeability (m/sec)	Remarks
Friston substation	TP330B	Lowestoft Formation Sand and Gravel)	0.30 – 1.0 [14.57 – 13.87]	2.16×10^{-6}	Test data extrapolated to calculate infiltration rate.

Site area	Hole ID	Strata	Test section depth (m bgl) [m AOD]	Permeability (m/sec)	Remarks
					One test run only.
	TP013A		0.25 – 1.0 [15.90 – 15.15]	N/A	Insufficient fall in water level to calculate infiltration rate
	TP013B		0.25 – 1.0 [15.48 – 14.73]	6.92×10^{-6}	Permeability reducing from test 1 to 3.
	TP014C		0.17 – 1.0	7.36×10^{-6}	Permeability reducing from test 1 to 3.

5.11 Groundwater

During the ground investigation, groundwater strikes and seepages were recorded in a number of the exploratory hole locations. It is possible that additional strikes were encountered in the Lowestoft Formation (Sand and Gravel) or Crag Group, however as water was added to assist drilling it is possible that these may have been masked.

Table 5.27 summarises the groundwater strikes recorded during the GI. The rose-to values from the strikes were not always recorded.

Table 5.27: Summary of groundwater strikes

Site area	Hole ID	Strata	Depth (m bgl) [m AOD]	Range of depth (m bgl) [m AOD]	Nature of strike	Remarks
Haul Road / River Fromus crossing	BH502	Alluvium	1.20 [7.54]	-	Seepage	No rise recorded
	BH502	Crag Group	4.5 [3.24]	Rose to 1.2 [6.54] after 20 minutes	Strike	
	BH502A	Alluvium	2.4 [5.45]	Rose to 1.4 [6.45] after 20 minutes	Strike	
	BH502A	London Clay Formation	22.0 [-14.15]	Rose to 4.0 [3.85] after 20 minutes	Strike	Large rise in water level noted
Converter Station	TP313	Lowestoft Formation	2.4 [22.58]	-	Seepage	Perched groundwater within granular bed/pocket
	TP315	Lowestoft Formation (Diamicton)	1.7 [21.45]	-	Seepage	Perched groundwater within gravel pocket
Red Penguin HDD	RedP-BH-1A	Tidal Flat Deposits	5.5 [-2.80]	Rose to 2.50 [0.20] after 20 minutes	Strike	

Groundwater monitoring standpipes were installed within six of the boreholes to target different strata. Groundwater monitoring was undertaken after the investigation, consisting of up to 8 no monitoring rounds over a period of approximately 3 months, between 28th September to 13th December 2023, with some of the early visits being undertaken whilst GI works were on-going. Following completion, to investigate longer-term seasonal variations in groundwater level, automatic data loggers were installed in four boreholes (BH308, BH310, BH502A and RedP-BH-1A) below the groundwater table.

Table 5.28 summarises the groundwater monitoring undertaken between September and December 2023. This was undertaken on an approximately bi-weekly basis throughout this period.

The monitoring suggested a range in groundwater levels between 0.36 – 17.32m bgl (1.44 – 17.03m AOD) across the site footprint, with several trends observed with the monitoring data presented in Figure 5.50, and summarised below:

- Groundwater was recorded in the Diamicton at the Converter Station, suggesting the presence to encounter perched water within the unit. This was also observed during the GI where granular beds were noted to be water bearing (see Table 5.27)
- The groundwater table at the Converter Station appeared to be around 7.5m AOD based on installations in BH308 and BH310 in both the Lowestoft Formation (Sand and Gravel) and Crag Group. This appeared to correlate with observations from groundwater level in the Crag Group adjacent to the River Fromus in BH502A (see diver data discussed below). Localised increases in water level were observed in the Lowestoft Formation in BH306, however this borehole was dry on most of the monitoring visits.
- Groundwater in RedP-BH-1A within the Coralline Crag Formation recorded water levels just above mAOD between c. 0.37- 1.44m AOD, correlating with expected groundwater levels due to its location adjacent to the Suffolk coastline.

Note that monitoring of diver data is ongoing at the time of writing, and this report will be subject to minor amendment following receipt of the outstanding diver data. The diver data received to date is presented in Figure 6.52 – Figure 6.55, and covers a period of six months between November 2023 and May 2024. The monitored groundwater measurements are shown on the Figures, with results suggesting a fairly stable groundwater level over this period with the exception of RedP-BH-1A, due to its tidal influence.

The data shows a relatively stable groundwater level over the monitoring period, with the exception of RedP-BH-1A which is tidally influenced. Groundwater levels at the Converter Station from BH 308 and BH310 correlate broadly with that observed in BH502A adjacent to the River Fromus, suggesting a similar groundwater level across the area.

Table 5.28: Summary of groundwater monitoring

Hole ID	Response zone depth (top to base, m bgl / m AOD)	Strata	Water depth (minimum, m bgl / m AOD)	Water depth (maximum, m bgl / m AOD)	Remarks
BH306	11 – 14 [14.24 – 11.24]	Lowestoft Formation – Sand and Gravel	14.02 [11.22]		Water only recorded on two visits (same measurement), remaining visits were dry.
BH308	15 – 21	Lowestoft Formation – Sand & Gravel / Crag Group	16.96 [7.45]	17.34 [7.04]	

Hole ID	Response zone depth (top to base, m bgl / m AOD)	Strata	Water depth (minimum, m bgl / m AOD)	Water depth (maximum, m bgl / m AOD)	Remarks
BH309	4.0 – 8.0	Lowestoft formation – Diamicton	7.55 [17.03]	7.82 [16.76]	
BH310	25.0 – 28.0	Crag Group	17.32 [7.47]	17.73 [7.06]	
BH502A	5.0 – 10.0	Crag Group	0.36 [7.49]	0.73 [7.12]	
RedP-BH-1A	20.5 – 23.0	Coralline Crag Formation	1.26 [1.44]	2.33 [0.37]	

Figure 5.50: Groundwater monitoring results

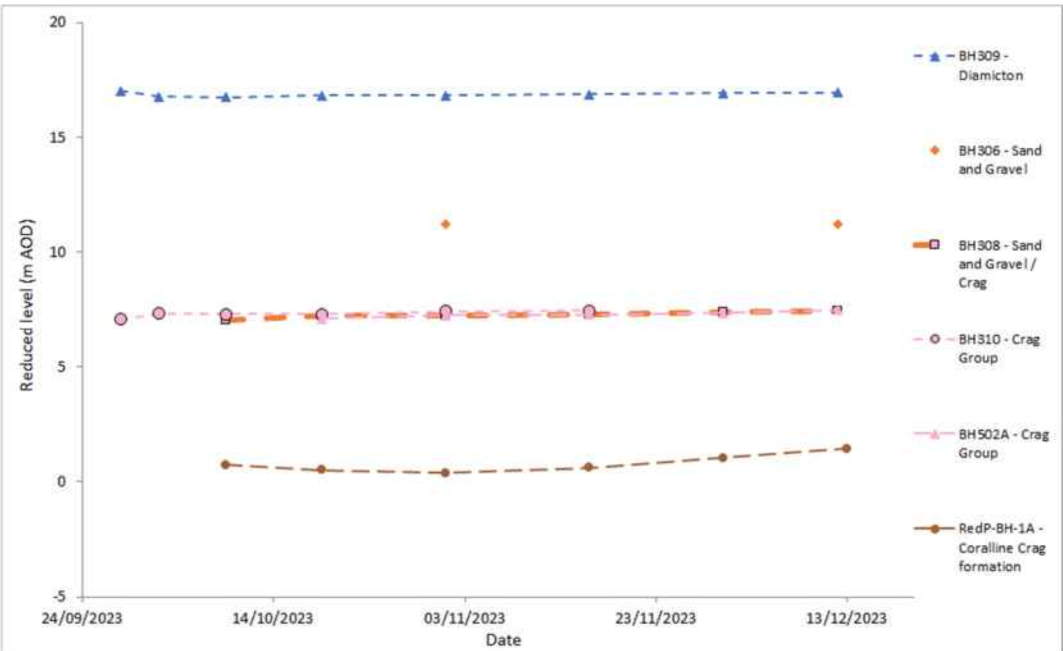


Figure 5.51: Automatic diver data logger measurements – BH308

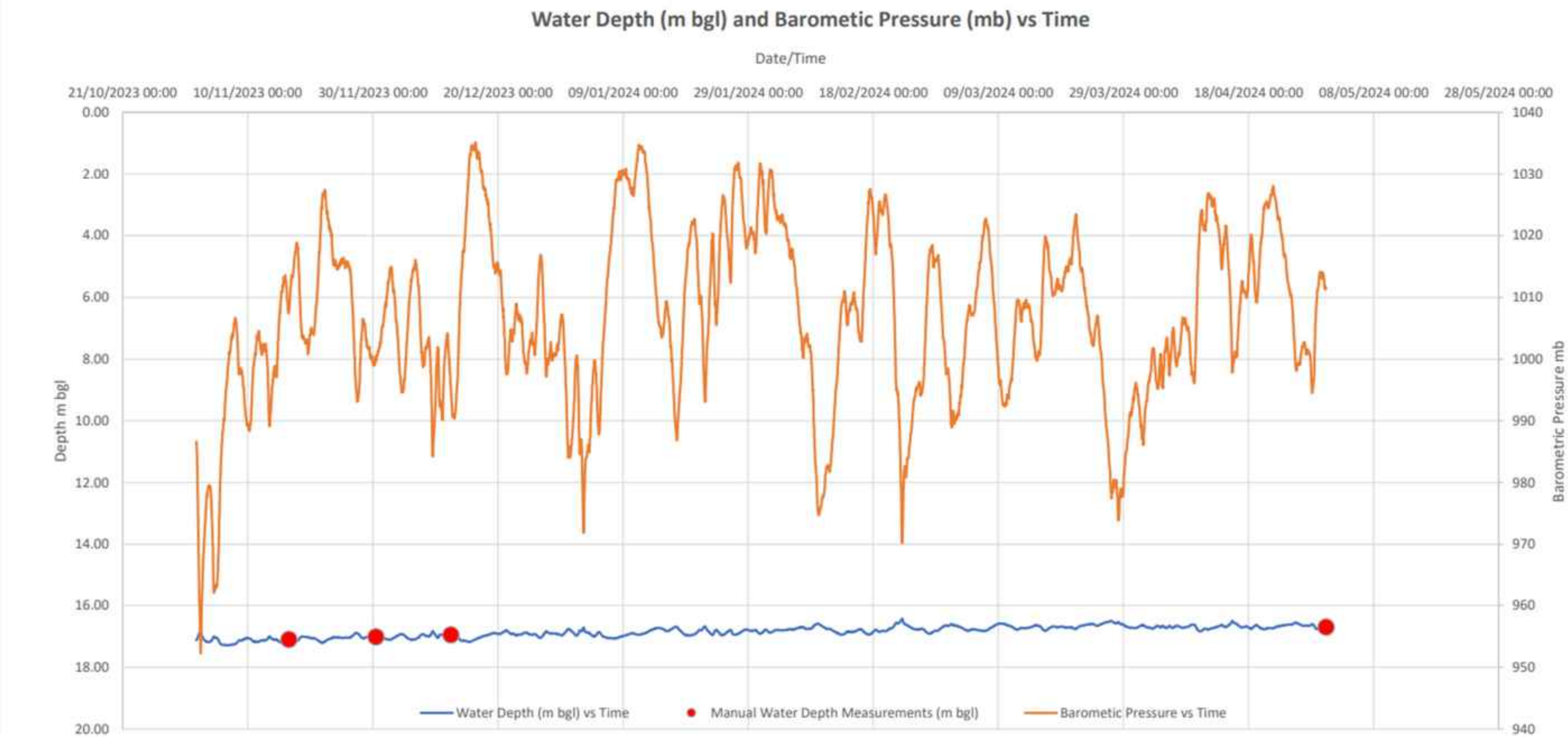


Figure 5.52: Automatic diver data logger measurements – BH310

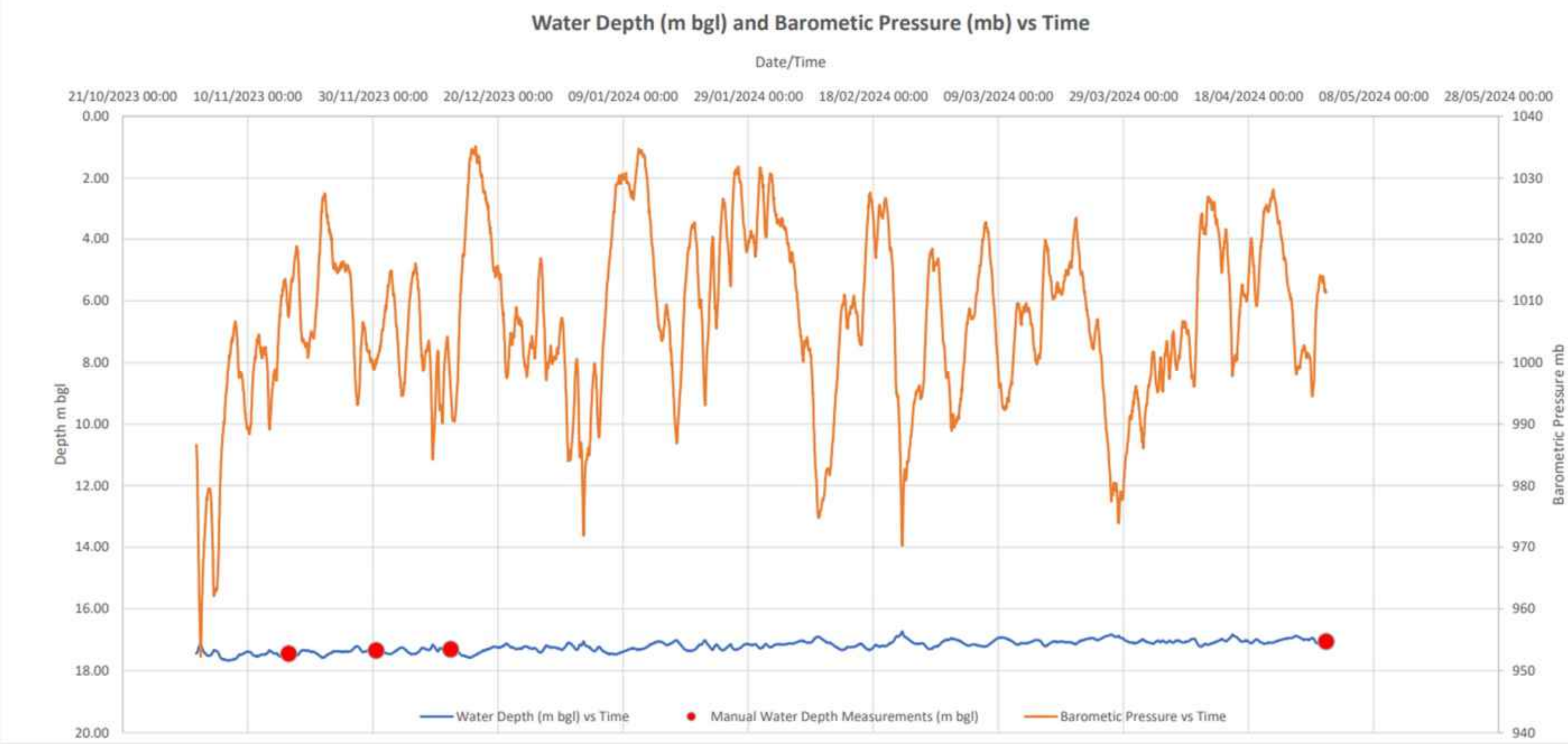


Figure 5.53: Automatic diver data logger measurements – BH502A

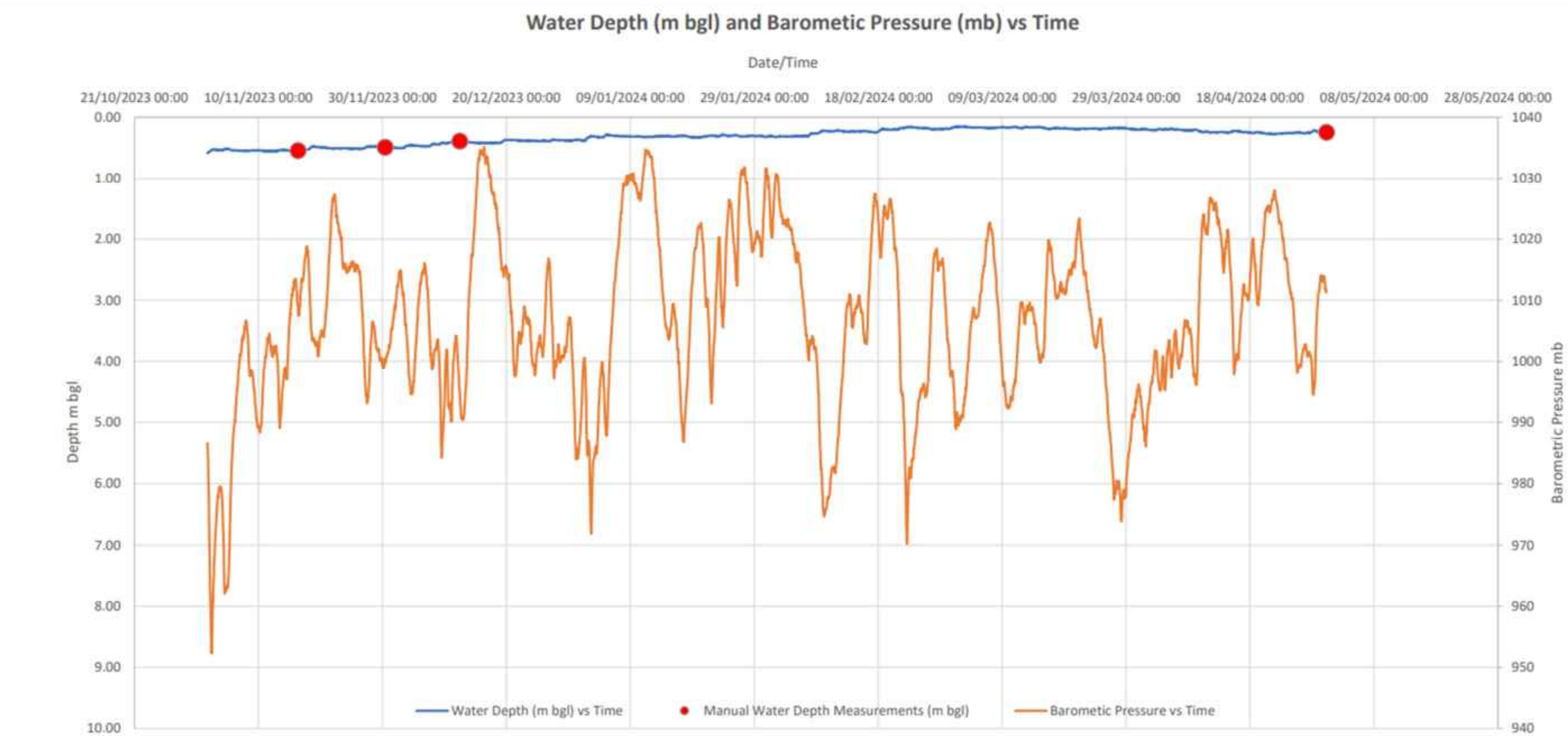
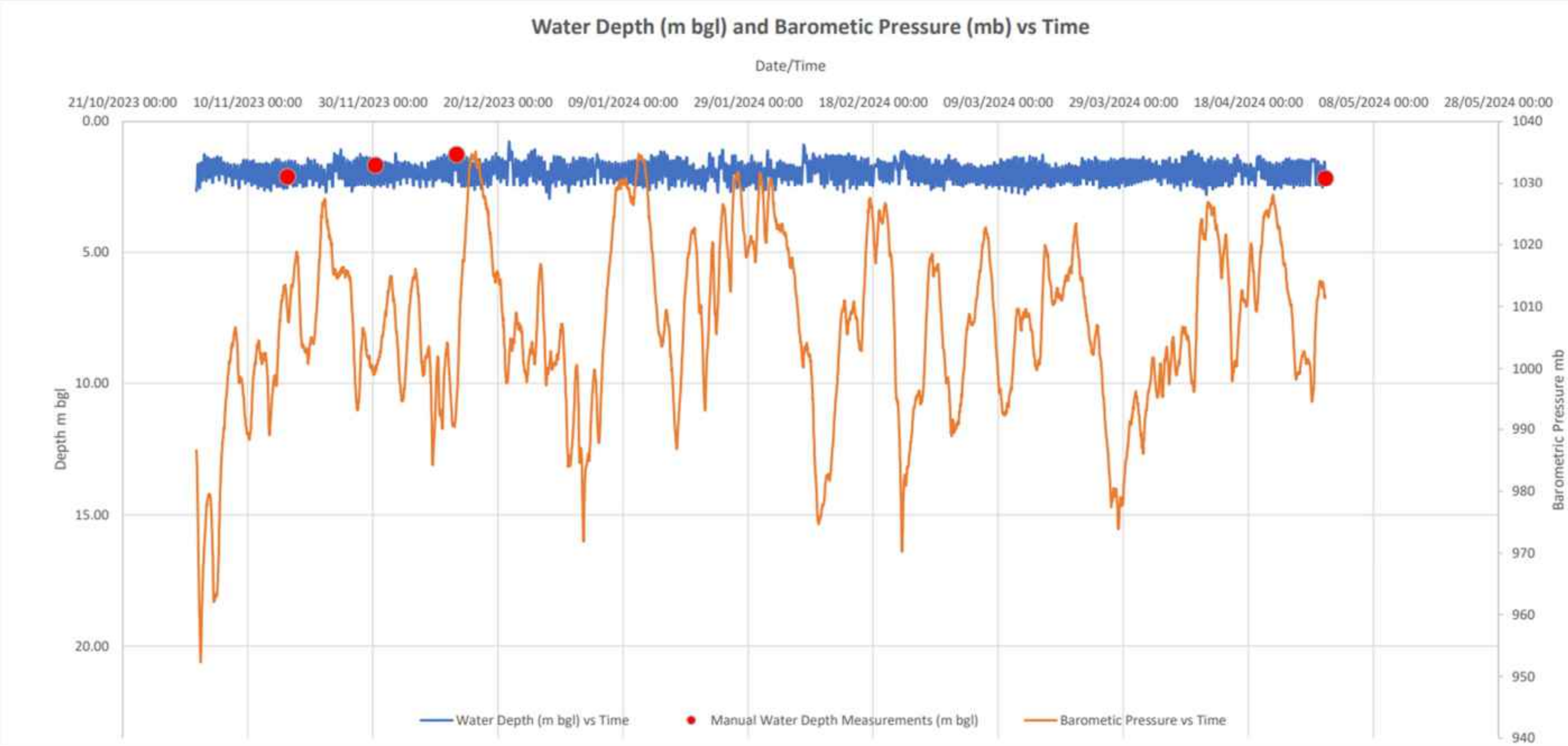


Figure 5.54: Automatic diver data logger measurements – RedP-BH-1A



5.12 Ground aggressivity

Sulphates in UK soils and groundwater can chemically attack concrete. BRE Special Digest 1: Concrete in Aggressive Ground has been used to determine the level of ground aggressivity at the site.

Sulphate and pH testing was conducted as part of the ground investigation of samples from the majority of geological units at the site which are anticipated to be encountered during construction works as well as groundwater, with the results summarised in Table 5.29. Reference should be made to Section 7.3 where these results are interpreted in context of the proposed works.

Table 5.29: Summary of ground aggressivity testing - soils

Strata	Parameter	No. of tests	Minimum	Maximum	Mean	Median
Made Ground	pH	2	6.1	7.5	6.8	6.8
	Water Soluble Sulphate (mg/l SO_4)	2	10*	1460	740	740
	Total Potential Sulphate (TPS, %)	1	1.65			
	Oxidisable Sulphides (OS, %)	1	0.78			
Alluvium	pH	1	7.3			
	Water Soluble Sulphate (mg/l SO_4)		10*			
	Total Potential Sulphate (TPS, %)	1	0.03			
	Oxidisable Sulphides (OS, %)	1	0.01			
Lowestoft Formation – Cohesive	pH	23	7.8	8.9	8.4	8.5
	Water Soluble Sulphate (mg/l SO_4)	23	10*	616.0	76.7	22.0
	Total Potential Sulphate (TPS, %)	22	0	3.4	0.3	0.1
	Oxidisable Sulphides (OS, %)	22	0	3.2	0.3	0
Lowestoft Formation – Granular	pH	11	6.9	8.7	8.0	7.9
	Water Soluble Sulphate (mg/l SO_4)	11	10*	51	16.2	10.0
	Total Potential Sulphate (TPS, %)	7	0.03	0.06	0.04	0.03
	Oxidisable Sulphides (OS, %)	7	0.01	0.04	0.02	0.01
Crag Group	pH	4	7.1	8.9	7.7	7.4
	Water Soluble Sulphate (mg/l SO_4)	4	11	347	145	111
	Total Potential Sulphate (TPS, %)	4	0.03	0.60	0.29	0.27
	Oxidisable Sulphides (OS, %)	4	0.01	0.52	0.24	0.22
Coralline Crag Formation	pH	3	8.4	8.9	8.6	8.5
	Water Soluble Sulphate (mg/l SO_4)	3	18	380	255.7	369

Strata	Parameter	No. of tests	Minimum	Maximum	Mean	Median
	Total Potential Sulphate (TPS, %)	1			3.51	
	Oxidisable Sulphides (OS, %)	1			3.32	
London Clay Formation	pH	4	6.3	8.2	7.5	7.9
	Water Soluble Sulphate (mg/l SO_4)	4	431	1660	962.3	879.0
	Total Potential Sulphate (TPS, %)	4	0.81	30.6	8.95	2.19
	Oxidisable Sulphides (OS, %)	4	0.65	30.06	8.66	1.96

* Where laboratory test results were returned less than the limit of detection (10mg/l for WSS), this has been reported at 10 mg/l to remain conservative.

A summary of the sulphate testing undertaken in groundwater samples is presented in Table 5.30. The results suggest the presence of seawater in RedP-BH-1A based on its elevated presence of chlorides.

Table 5.30: Summary of ground aggressivity testing – groundwater

Hole ID	Strata	Parameter	No. of tests	Minimum	Maximum	Mean	Median
BH308	Lowestoft Formation – Sand & Gravel / Crag Group	pH	3	7.3	7.7	7.4	7.4
		Sulphate (mg/l)	3	236.0	256.0	247.7	251.0
		Magnesium (mg/l)	1			28.4	
		Chloride	1			168	
		Nitrate	1			<0.1	
		Ammonium / ammoniacal N as NH_4	1			0.1	
BH310	Crag Group	pH	3	7.4	7.5	7.4	7.4
		Sulphate (mg/l)	3	91.0	99.0	94.0	92.0
		Magnesium (mg/l)	1			10.0	
		Chloride	1			46.34	
		Nitrate	1			0.30	
		Ammonium / ammoniacal N as NH_4	1			0.11	
BH502A	Crag Group	pH	3	7.7	7.9	7.8	7.7
		Sulphate (mg/l)	3	80.0	84.0	81.7	81.0
		Magnesium (mg/l)	1			17.4	
		Chloride	1			65.81	
		Nitrate	1			36.5	
		Ammonium / ammoniacal N as NH_4	1			0.17	
		pH	3	7.1	7.8	7.4	7.2

Hole ID	Strata	Parameter	No. of tests	Minimum	Maximum	Mean	Median
RedP-BH-1A	Coralline Crag Formation	Sulphate (mg/l)	3	2	2622	1671.3	2390
		Magnesium (mg/l)	1	1210			
		Chloride	1	17800			
		Nitrate	1	-			
		Ammonium / ammoniacal N as NH_4	1	1.33			

5.13 Soil resistivity

This section summarises a series of resistivity tests undertaken at the site and within laboratory testing, utilising various methods.

5.13.1.1 Geophysical surveys

A Vertical Electrical Sounding (VES) survey was carried out at the proposed converter station, to determine the apparent resistivity of the subsurface for earthing design. The methodology and results are presented within Appendix C of the factual report.

The results of the resistivity survey are to be utilised in the earthing design, which is to be documented separately, therefore further discussion is not within the scope of this report.

5.13.1.2 Laboratory soil resistivity

A series of twelve laboratory soil resistivity tests were undertaken at the Converter Station site, summarised in Table 5.31 and are presented in Figure 5.55. The results broadly indicate a decreasing soil resistivity with depth in the Lowestoft Formation (Cohesive), with granular beds resulting in greater resistivity. The tests were undertaken at an as received moisture content, and were remoulded to maximum achievable density. It should be noted that as these were undertaken on bulk samples, and therefore their moisture contents should be treated with appropriate caution.

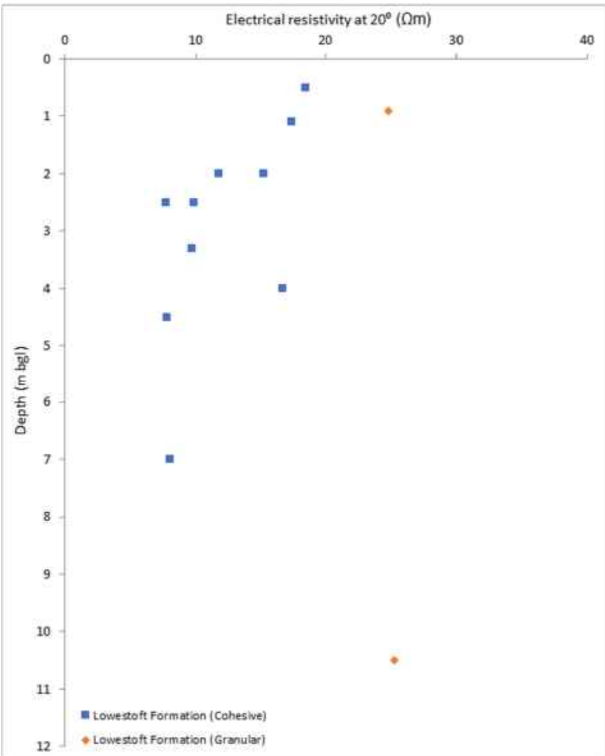
The results of the soil resistivity testing are to be utilised in the earthing design which is to be documented separately, therefore further discussion is not within the scope of this report.

Table 5.31: Laboratory soil resistivity summary

Hole ID	Stratum	Depth (m bgl)	Moisture content (%)	Remoulded bulk density (Mg/m^3)	Electrical resistivity at 20° $\Omega(m)$
BH306	Lowestoft Formation (Cohesive)	2.5	36.5	1.83	7.73
BH307	Lowestoft Formation (Granular)	10.5	16.1	1.88	25.25
BH308	Lowestoft Formation (Cohesive)	2.5	19.9	2.02	9.88
BH309	Lowestoft Formation (Cohesive)	4.5	20.5	2.02	7.83
BH310	Lowestoft Formation (Cohesive)	7.0	24.0	1.97	8.01
TP310	Lowestoft Formation (Cohesive)	1.10	17.0	1.91	17.39

Hole ID	Stratum	Depth (m bgl)	Moisture content (%)	Remoulded bulk density (Mg/m^3)	Electrical resistivity at 20° $\Omega(m)$
TP311	Lowestoft Formation (Granular)	0.90	18.8	2.05	24.80
TP312	Lowestoft Formation (Cohesive)	2.0	17.7	1.91	11.75
TP313	Lowestoft Formation (Cohesive)	0.50	18.4	1.84	18.46
TP314	Lowestoft Formation (Cohesive)	2.0	19.4	1.89	15.19
TP316	Lowestoft Formation (Cohesive)	3.3	20.8	1.87	9.69
TP317	Lowestoft Formation (Cohesive)	4.0	19.1	1.85	16.71

Figure 5.55: Laboratory electrical resistivity versus depth



5.13.1.3 Thermal resistivity

In-situ and laboratory measurements of thermal resistivity were undertaken along the length of the cable route and at the proposed Converter Station in a series of trial pits, to inform cable design through obtaining thermal conductivity values. The results are presented in the factual report and are summarised in Table 5.32.

In-situ tests were completed at three depths per location at 0.70m, 0.90m and 1.1m bgl.

Interpretation of these results are documented separately as part of the cable design, and are therefore not reviewed in detail in the scope of this report. Any results considered to be anomalous or not representative of the material, for example containing high standard deviations from the test, have been manually reviewed and not included in the below summary.

Table 5.32: In-situ thermal conductivity testing summary

Material	No. of tests	Thermal conductivity (W / m K)				Temperature (°C)
		Minimum	Maximum	Average	Median	
Converter Station						
Lowestoft Formation – Cohesive	24	0.82	3.40	2.07	2.03	15.3 – 24.3
Cable route						
Lowestoft Formation – Cohesive	5	1.91	3.08	2.35	2.29	16.1 – 16.8
Lowestoft Formation – Granular	16	0.60	4.03	2.17	2.20	15.6 – 20.6
Crag Group	3	1.25	2.42	1.72	1.71	17.7 – 18.5

Note – Each test (e.g. 0.70m, 0.90m and 1.1m bgl) comprised a series of three test measurements at each depth. Any tests thought to be anomalous or not representative have been removed and are not presented in the above summary

A summary of the laboratory thermal resistivity testing undertaken is presented in Table 5.33. Laboratory thermal resistivity measurements generally comprised three sub samples per test including testing at various moisture contents including in-situ moisture, moisture content of <5%, and a moisture content approximately halfway between in-situ and 0%, with remoulding to maximum bulk density (where possible). It should be noted that this was not always possible, particularly for the samples at lower moisture contents.

Table 5.33: Laboratory thermal conductivity testing summary

Material	No. of tests	Thermal conductivity (W / m K)				Temperature (°C)
		Minimum	Maximum	Average	Median	
Converter Station						
Lowestoft Formation – Cohesive	13	0.46	1.93	1.18	1.13	13.2 – 22.3
Cable route						
Lowestoft Formation – Cohesive	3	0.74	2.50	1.55	1.73	18.9 – 21.8
Lowestoft Formation – Granular	5	0.69	2.77	1.77	1.74	17.9 – 21.4
Crag Group	1	1.77				20.8
HDD						
Coralline Crag Formation	6	0.35	1.34	1.01	1.06	17.4 – 22.0
London Clay Formation	3	0.45	1.37	0.90	0.82	13.0 – 22.2

6 Geo-environmental considerations

Alongside this report, a Generic Quantitative Risk Assessment (GQRA) has been produced by Mott MacDonald Limited. Reference should be made to the report for geo-environmental information.

- Mott MacDonald Limited, Sea Link FEED, Generic Qualitative Risk Assessment (GQRA) – Friston, May 2024. Document reference: SEAL-MMD-SEAL-ENG-REP-0690

7 Preliminary ground models and geotechnical parameters

This section summarises a series of preliminary ground models and geotechnical parameters based on information presented in the above sections.

This assessment is based on the geological unit allocations and information available at the time of writing from current ground investigation information. These parameters and ground models are subject to review and development to inform specific geotechnical design aspects and are to be reviewed upon the receipt of any additional GI information at later design stages.

7.1 Ground models

A series of ground models have been derived for the site based on freely available information and site-specific ground investigation. These are summarised below. The spatial distribution of these across the site is presented in Section 4 and Appendix B. For further details on the geological strata reference should be made to earlier Sections in this report, and to Section 7.2 which discusses preliminary geotechnical parameters.

7.1.1 Converter Station

The preliminary ground model for the Converter Station is presented in Table 7.1. Reference should be made to Section 4.2 where a sketch cross-section is presented through the Converter Station site, with its location shown in Figure 4.1.

Table 7.1:Preliminary ground model – Converter Station

Strata	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil	0.0	0.30	0.30
Lowestoft Formation – Diamicton	0.30	9.3	9.0
Lowestoft Formation – Sand and Gravel	9.3	13.0	3.7
Lowestoft Formation – Sand and Gravel **OR** Lowestoft Formation – Diamicton (Cohesive)[1]	13.0	17.0	4.0
Crag Group	17	>28.45*	>12.75**

*Base depth not proven **Thickness not proven

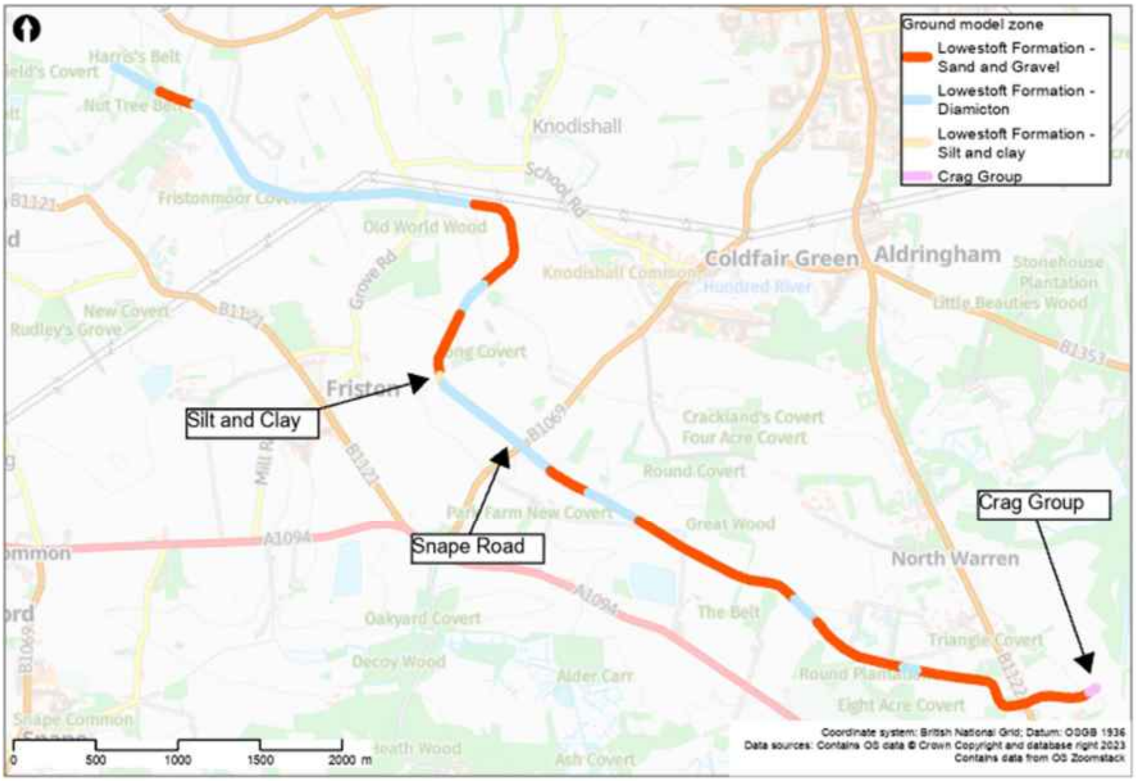
[1] The bed of cohesive material at depth in the Lowestoft Formation was only locally encountered. Dependent on the design scenario, it may provide a more conservative design analysis to assume this material is present (for example assessments of foundation settlement).

Groundwater is considered to be deep for the purpose of design (c. 15m bgl). However, it is possible perched groundwater could be encountered associated with localised granular beds within the Diamicton.

7.1.2 Cable route

The cable route extends from the Converter Station site near Saxmundham, to the eastern end of the project where it connects to off-shore elements via trenchless methods (HDD). Along the length of the site, there are various different geological strata encountered. A sketch plan has been produced and is presented in Figure 7.1 to show the spatial distribution of the ground model across this area.

Figure 7.1: Cable route – Ground model zone sketch



The cable route has been subdivided based on the key superficial deposits, as well as minor areas of bedrock of the Crag Group, likely to be encountered following interpretation of the 2023 site-specific GI, the 2021 GI undertaken for the SPR project as well as BGS information. The length of the scheme that these deposits could occupy is also summarised below. The cable is anticipated to be constructed in shallow trenches of depth up to c. 1.5 – 2.0m bgl. Based on this depth of construction, the below is briefly summarised to indicate the materials likely to be present, as well as any local variations observed in the above sections. Further details on the likely engineering descriptions of the materials are captured in Sections 5 and 6.

- Lowestoft Formation – Sand and Gravel – c. **4500m**
  - Predominantly encountered as a sand which can be water bearing, though in vicinity of Snape Road may be locally encountered as a sandy SILT or sandy silty CLAY (possible Silt and Clay), and the fines and/or gravel content of the material could vary.
- Lowestoft Formation – Diamicton – c. **4000m**
  - Predominantly firm to very stiff with depth slightly sandy slightly to gravelly CLAY with low cobble content. May be locally soft to firm, and contain a greater granular content in vicinity of Snape Road. May contain water bearing granular beds.
- Lowestoft Formation – Silt and Clay – c. **50m**
  - No exploratory holes undertaken where this unit was recorded. It is possible that this was recorded in vicinity of Snape Road (see above sections for further detail), and could be encountered as sandy silty CLAY or sandy SILTs. These deposits are generally indicated to be present between the boundary of the Diamicton and Sand and Gravel.
- Crag Group – c. **50m**

  - No exploratory holes undertaken where this unit was recorded. Based on engineering descriptions across the wider site, likely to be encountered as a sand (see above sections for further details).
- Groundwater – No groundwater was recorded during the trial pits undertaken along the cable route. It is recommended to remain conservative for the purpose of design that groundwater is assumed to be present at approximately 2m bgl.

7.1.3 Construction compounds and access routes

7.1.3.1 Construction compounds

A series of construction compounds are proposed along the length of the project. The location of these are presented in Figures 5.1 – 5.3. The ground conditions encountered at the compounds generally comprises two dominant geological strata including the Lowestoft Formation – Diamicton, or Sand and Gravel. The conditions associated with these are summarised below. It is recommended that a conservative groundwater level is assumed as 2m bgl for these areas despite no groundwater being recorded at the time of investigation (except the Permanent access route).

- Permanent access route (to Converter Station)
- Blackheath Farm
- Off-shore HDD connection

In addition, the following construction compounds have been assessed as part of other site ground models:

- Converter Station construction compound
  - Summarised in Section 7.1.1
- Two construction compounds associated with the Friston substation
  - Summarised in Section 7.1.3.2.
- Snape Road to Manor Farm
  - Summarised in 7.1.2

The Lowestoft Formation (Sand and Gravel) is anticipated to be encountered at several of the construction compounds – summarised below in Table 7.2. It should be noted that:

- There is potential to encounter localised Alluvium along the permanent access route to the Converter Station, reference should be made to Section 7.1.3.2 where this is summarised; and,
- It is possible the Crag Group may be encountered at the Offshore HDD connection compound, although no GI was undertaken in its footprint during this stage of work. At this stage, the ground model has been prepared based on the closest exploratory hole (TP222A) located approximately 65m south-west of the footprint.

Table 7.2:Preliminary ground model – Permanent access route (to Converter Station), Blackheath Farm, and Offshore HDD connection

Strata	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil	0	0.30	0.30
Lowestoft Formation – Sand & Gravel OR Crag Group (Offshore HDD connection only)	0.30	3.80	3.50

7.1.3.2 Access routes

This section summarises ground models associated with the site access routes for the Converter Station and Friston Substation.

Permanent access – Converter Station

The ground model for the permanent access option is presented in Table 7.3. Reference should be made to Section 4.2 where a sketch geological section is shown through this area from west to east, as the ground model has been sub-divided based on ground conditions encountered across the River Fromus.

It is assumed that if locally present, Made Ground may be removed and replaced. Topsoil is anticipated to require removal during construction.

Table 7.3: Preliminary ground model – Permanent access option (Converter Station)

Strata	Top Depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
In proximity to River Fromus			
Alluvium (Cohesive)	0	3.0	3.0
Crag Group	3.0	18.0	15.0
London Clay Formation	18.0	>25	>7.0
East of River Fromus			
Topsoil	0	0.30	0.30
Lowestoft Formation – Diamicton [Recorded in eastern area of access road only, thins to the west]	0.30	3.4 - >4.0	>4.0
Lowestoft Formation – Sand and Gravel. [Recorded	3.7	>0.30	>0.30

Groundwater is recommended to be assumed at 2m bgl along the majority of the access route, however in proximity to the River Fromus a groundwater level of 1m bgl is recommended.

Friston substation connection and substation access road

The ground model for the Friston substation connection and the substation access road is summarised in Table 7.4. It should be noted that construction compounds are proposed at the substation connection, and are captured in the below table summary.

Table 7.4: Preliminary ground model – Friston substation connection and access road

Strata	Top Depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Substation access route, and western end of substation connection			
Topsoil	0	0.40	0.40
Lowestoft Formation – Diamicton [Diamicton thins eastwards, and is absent along eastern end of the access road and parts of the substation connection]	0.40	1.0 – 3.6	0.60 – 3.6
Lowestoft Formation – Sand and Gravel [Not encountered along the western area of the access road]	0.40 – 4.0	3.5 – >4.0*	2.5 – >3.1
Crag Group	3.5	15.0*	>11.5**
Eastern end of substation connection			
Topsoil	0	0.40	0.40

Strata	Top Depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Lowestoft Formation – Diamicton [Thickness may vary across site area]	0.40	1.5 – >3.2*	1.1 – >2.8**
Lowestoft Formation – Sand and Gravel [May be locally encountered beneath Diamicton, and could be underlain by Crag Group at depth]	1.5	3.5*	>2.0**

*Base depth not proven **Thickness not proven

Groundwater is assumed to be present at approximately 8m bgl based on exploratory holes in vicinity of the site.

7.1.4 Red Penguin

The ground conditions are summarised from the Red Penguin exploratory holes within Appendix B. No preliminary ground model has been included in this section as the design of the trenchless elements lies with Red Penguin and will be reported separately by others.

7.2 Geotechnical characteristic parameters

A series of characteristic preliminary geotechnical parameters have been derived from the information obtained during the ground investigation and relevant historical site information.

The parameters have been derived based on the strata likely to be present and information presented in the above sections alongside published correlations available for the materials, papers and standards (where relevant) as well as engineering judgement. The below sections summarise the relevant parameters, with a summary of the parameters presented in Section 8.2.4.

It is understood that based on the current proposed design that any Topsoil is likely to be stripped from the site during construction, and in areas of the cable route this is envisaged to be reinstated after construction. No engineering properties are provided for Topsoil.

In addition, no engineering properties have been included for Made Ground, as this was only locally encountered, and the London Clay Formation has not been presented at it is unlikely to be encountered within the influence zone of any of the currently proposed works.

No properties of the materials anticipated to be encountered along the Red Penguin off-shore HDD connection have been included, as it is understood this will be reported separately and is the design responsibility of Red Penguin.

7.2.1 Unit Weight

Unit weight has been derived from various methods including BS 8004:2015 (Section 4.3.1, soils above / below the groundwater table), as well as information presented in Sections 5 and 6 including bulk density tests from undisturbed samples, where available. The rationale for the selected parameters is explained below:

- Alluvium – Based on BS 8004:2015 assuming a very low to low strength clay below the groundwater table from the engineering log descriptions.
- Lowestoft Formation – Diamicton – Based on bulk density test results and review of strength data, a bulk density of 2.06 Mg/m^3 has been considered to derive unit weight.
- Lowestoft Formation – Sand and Gravel – Based on 8004:2015 assuming a medium dense to dense sand above the groundwater table from the engineering log descriptions.

- Lowestoft Formation – Sand and Gravel (**local cohesive beds**) – Based on BS 8004:2015 assuming a low strength clay / silt above the groundwater table from the engineering log descriptions.
- Crag Group – Based on two bulk density test results (lower result of 2.04 Mg/m^3) as well as BS 8004:2015 assuming a very dense sand

7.2.2 Undrained Shear Strength

Undrained shear strength has been derived based on data presented in Section 6 as well as the engineering log information captured in Section 5. This includes review of in-situ and laboratory measurements of undrained shear strength, and consideration of any testing limitations such as sample preparation – where for example in the Diamicton, several samples failed sample preparation checks related to flatness and/or perpendicularity prior to testing.

The rationale for the selected parameters is explained below:

- Alluvium – 20kPa – Limited soil classification and in-situ testing undertaken due to limited thickness. Based on engineering log descriptions, engineering judgement.
- Lowestoft Formation – Diamicton – 75kPa between 1m to 2.5m bgl, increasing by c. 17.5kPa per metre to a maximum of 180kPa at c.8.5m bgl based on various in-situ testing (SPT) and laboratory testing (UUT, CUT tests).
- Lowestoft Formation – Sand and Gravel (**local cohesive beds**) – Based on in-situ testing, engineering log descriptions and engineering judgement a value of 40kPa has been selected.

7.2.3 Effective angle of shearing resistance and cohesion

7.2.3.1 Cohesive deposits

The effective angle of shearing resistance has been derived for the cohesive deposits based on correlations presented in BS 8004:2015 and the use of site-specific plasticity data, as summarised below. It should be noted as discussed in Section 5 that consolidated undrained triaxial testing has not been relied upon for deriving these parameters (reference should be made to Section 5 for further information):

- Alluvium – Based on engineering judgement and assuming a low plasticity material from the engineering log descriptions (due to significant granular content generally present), alongside guidance within BS8004:2015.
- Lowestoft Formation – Diamicton – This has been selected based on a conservative plasticity index of 38 using methodology from BS 8004:2015 as well as Sorensen and Okkels (2013) who discuss a formulae for stiff matrix-dominated soils.
- Lowestoft Formation – Sand and Gravel (**local cohesive beds**) – Locally, where encountered as a cohesive material this has been selected based on an upper-bound plasticity index of 23 alongside guidance within BS 8004:2015.

7.2.3.2 Granular deposits

For the granular deposits, the angle of friction has been determined based on BS 8004:2015 utilising available information for the materials including particle grading curves, particle angularity, engineering log descriptions, in-situ SPT test results (relative density), laboratory measurements of effective strength properties (small shear box tests) as well as engineering judgement. This is summarised below:

- Lowestoft Formation – Sand and Gravel – Predominantly recorded on the engineering logs as a uniformly graded sand with some fines and/or gravel content. The unit generally has a coefficient of uniformity of greater than 2, suggesting it is evenly graded in accordance with BS 8004:2015. Particle angularity has not been reviewed in detail as gravel did not always form a significant component of the particle size distribution. Based on this, this unit has been assigned a phi' value of 32º.

- Crag Group – predominantly recorded on the engineering logs as a uniformly graded sand with a coefficient of uniformity of greater than 2, suggesting it is evenly graded in accordance with BS 8004:2015. Due to limited gravel content, particle angularity has not been reviewed in detail, as gravel did not always form a significant component of the particle distributions. Based on this, this unit has been assigned a phi' value of 34º.

7.2.4 Coefficient of Volume Compressibility

The coefficient of volume compressibility (m_v) has been derived based on SPT values using empirical relationships presented within Stroud and Butler (1978), oedometer testing where available, engineering judgement and published values. This has only been considered for the cohesive materials which are present near-surface and likely to be loaded as part of the proposed works, including the Lowestoft Formation (Diamicton) and Alluvium. Published

- Alluvium - m_v selected as 0.30 based on results of limited in-situ testing and engineering judgement and published values for similar materials
- Lowestoft Formation – Diamicton – m_v selected as 0.15 between 1 – 2m bgl, reducing to 0.05 at 9m bgl (c. 0.015 per metre)

7.2.5 Characteristic parameters – summary

Table 7.5 presents a summary of the characteristic parameters from information presented in the above sections. Reference should be made to the above sections for further information on their derivation.

As discussed above, the London Clay Formation has not been included in the below review as it is located a significant depth below any likely influence zone from construction.

Table 7.5: Preliminary characteristic geotechnical parameters

Strata		Unit Weight (kN/m^3)	Undrained shear strength (kPa)	Effective angle of internal friction (º)	Effective cohesion (c'. kPa)	Coefficient of volume compressibility, m_v (m^2/MN)
Alluvium		17.0	20.0	24	0	0.30
Lowestoft Formation – Diamicton		20.0	75 – 180 (**see Section 8.2.2**)	22	0	0.15 to 0.05 (see Section 8.2.4)
Lowestoft Formation – Sand and gravel	Granular	18.0	N/A	32	0	N/A
	Local cohesive beds	18.0	40	25	0	N/A – local only
Crag Group		20.0	N/A	32	0	N/A

7.3 Ground aggressivity

In accordance with BRE Special Digest 1:2005 Concrete in Aggressive Ground, the results detailed in Section 5.12 for the soil and groundwater samples taken during the GI have been used to calculate the Characteristic values, the Design Sulphate (DS) class and Aggressive Chemical Environment for Concrete (ACEC) class.

It is possible that disturbance of some strata could result in additional sulphate based on the results presented in Section 5.12, therefore selected strata (and known pyritic bearing strata) are assessed as pyritic.

It should be noted that similarly to Section 7.2, the London Clay Formation is anticipated to be below the influence zone of the proposed works. Therefore, it has not been covered in this section in detail. Should this change as the design is developed, it is recommended that this is reviewed accordingly.

The below summary assumes groundwater is mobile, which is believed to be the case based on groundwater levels encountered at the site during the GI.

It is anticipated that shallow foundations will form the dominant foundation solution at the Saxmundham Converter Station site, with the cable route being proposed predominantly within open cut as well as selected areas where trenchless solutions (i.e. HDD's) are proposed. These types of foundation and level of excavation are likely to result in disturbance of any material which may contain pyrite which could oxidise (see Table 8.7). However, both potential design scenarios are presented below from water soluble sulphate and total potential sulphate dependent on the design task.

As the test result in Made Ground is interpreted to be reworked from Alluvium, it has been combined together when assessing the Design Sulphate class.

The below classes assume groundwater is mobile.

Table 7.6: Summary of ground aggressivity results (No disturbance of pyrite bearing strata)

Strata	**Characteristic values**		**Design Sulphate Class (DS)**	**ACEC Class**
	pH	Water Soluble Sulphate (mg/l SO_4)		
Alluvium and Made Ground (reworked Alluvium)	6.1	1460	DS-2	AC-2
Lowestoft Formation – Diamicton	7.8	543.5	DS-2	AC-2
Lowestoft Formation – Sand and Gravel	7.2	44.0	DS-1	AC-1
Crag Group	7.1	347	DS-1	AC-1

Table 7.7: Summary of ground aggressivity results (Disturbance of pyrite bearing strata)

Strata	**Characteristic values**		**Design Sulphate Class (DS)**	**ACEC Class**
	pH	Total Potential Sulphate (%)		
Alluvium and Made Ground (reworked Alluvium)	6.1	0.01	DS-1	AC-1
Lowestoft Formation – Diamicton*	7.8	0.91	DS-2	AC-2
Lowestoft Formation – Sand and Gravel	7.2	0.04	DS-1	AC-1
Crag Group	7.1		DS-2	AC-2

*Note, from assessment of Total Potential Sulphate, the amount of oxidisable sulphides was only greater than 0.30% in c. 9% of samples, therefore it is considered unlikely that significant quantities of pyrite are present within the Diamicton. However, assessment of samples where elevated TPS was recorded could suggest a Design Class of DS-3, AC-3 to remain conservative.

Aggressivity tests undertaken in groundwater suggested a Design Sulphate Class of DS-1, AC-1 was appropriate for testing at the Converter Station and River Fromus (Lowestoft Formation and Crag Group), and testing undertaken at the Red Penguin HDD connection indicated a Design Class of DS-3, AC-3.

8 Engineering Considerations

Following completion of the site-specific GI, there is an opportunity to review the design proposals and constraints / considerations with respect to the ground conditions. These are summarised in the below sections, based on information presented on the drawings presented in Appendix A.

8.1 General

The ground conditions anticipated to be encountered during construction are summarised in the above sections, and comprise the following:

- Lowestoft Formation – Diamicton on higher ground, which forms a plateau across the wider district
- Lowestoft Formation – Sand and Gravel with minor cohesive glacial deposits (silt and clay) in areas of lower elevation
- Locally, the Crag Group may be encountered in river valleys and close to the coast
- Alluvium is also likely to be locally present where water courses cut into the Crag Group, particularly the River Fromus south of Saxmundham.

In order to construct the works associated with the new cable route, convertor station and substation connection, a number of ground engineering activities are required. These are detailed in the below sections.

8.2 Cable route

8.2.1 Trenches

A typical cross-section of an open cut trench is presented within Appendix A, alongside typical construction easements along the proposed works corridor.

The cable trenches are anticipated to be up to c. 1.5 – 2m in depth, and will predominantly encounter the Diamicton or Sand and Gravel of the Lowestoft Formation (locally the silt and clay sub-member may be found).

Excavation is anticipated to be straightforward and side slopes will be stable with a suitable temporary batter in granular deposits (say 1V:1.5H) or installation using a temporary support system e.g. drag box may also locally be appropriate. Groundwater is not expected in the majority of the cable trench excavation although there will be localised seepages and potential for perched water which may reduce stability. Shallower batter angles may be required should groundwater be encountered, and these are envisaged to be controllable with simple sump-pump drainage. This could lead to localised trench instability which can be managed during construction.

Cement Bound Sand (CBS) would be used as backfill above and below the cables. The trench will then be backfilled with well compacted thermally suitable backfill. The sand required for the CBS will need to comply with BS 12620:2002+A1:2008 – Aggregates for concrete. Based on a high-level review, it is likely that c. 50% of the site-won material may have too greater fines content for filler aggregate. Additional laboratory testing is likely to be required to fully determine the suitability of the material for re-use as CBS, and it is recommended this is undertaken at the next design stage.

It is envisaged that the majority of the Lowestoft Formation – Diamicton would be suitable for re-use as a general backfill material, though an element of treatment such as by drying and/or wetting could be required. The following should be noted:

- The Diamicton contains local granular pockets and lenses which, if water bearing, may locally render the material unsuitable without drying. This is not a problem in good weather but can lead to problems where drying is constrained by weather (particularly over winter months).
- It is possible that obstructions may be present in the unit despite not being recorded in the GI, including for example cobbles and boulders.
- The high Chalk content of the Diamicton can lead to re-cementation on compaction. Also, it can lead to rapid drying of the fill between excavation and deposition. This may lead to two possible issues:
  - Excavation of the fill may be more difficult than planned if it has recemented.
  - Compacting dry of optimum can lead to high air voids in the fill, and therefore a poorer compaction.
- Due to the porosity of the Chalk, the surface layer of the Diamicton fill may be susceptible to frost-heave resulting in a reduced bearing capacity.

Topsoil should be stripped and stockpiled for replacement on completion of the backfilling.

8.2.2 Structures

Joint bays are proposed at regular intervals along the cable alignment, to connect lengths of cable through the ducting, which are proposed to be reinforced concrete ground bearing slabs. In addition, other structures such as culverts are required as part of the haul road to allow construction vehicles to cross over small drainage ditches.

Based on the materials which are likely to be encountered, and as these concrete elements are envisaged to be relatively lightly loaded, it is likely that bearing onto or within the underlying Diamicton or Sand and Gravel of the Lowestoft Formation would be suitable. The formation should be reviewed during construction with removal of any soft/loose spots, and it should be protected from inclement weather. Any concrete should be designed in accordance with the relevant concrete class (see Section 7.3), and design of elements should be assessed at the next stage.

In addition to the above, structures including for example new pylons and pylon modification works are required in vicinity of the proposed Friston substation. Dependent on the structural loads, it is possible that a deeper foundation solution such as piles could be required. It is recommended that this is assessed in detail at the next design stage.

8.2.3 Trenchless crossings

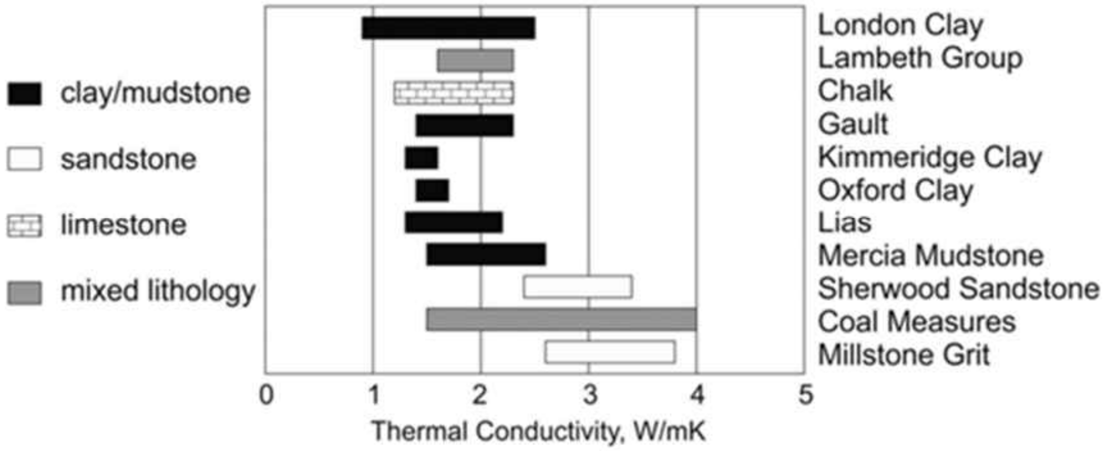
No trenchless crossings are anticipated as part of the on-shore part of the scheme. Should during design development trenchless crossings be required as part of the on-shore element, it is likely that further GI would be required.

The main trenchless crossing is proposed as part of the offshore connection, which is the design responsibility of Red Penguin. The variable ground conditions should be considered by the specialist trenchless method (i.e. HDD) Contractor and considered during design and construction. Dependent on the time of year, it is possible that groundwater control could be required for launch and reception pits. Groundwater was recorded in RedP-BH-1A at shallow depths between 1.23 – 2.33m bgl.

8.2.4 Thermal Conductivity

In-situ thermal conductivity tests were carried out within trial pits along the cable route, summarised within Section 5.13. The recorded thermal conductivity values generally range between 0.60 – 4.03 for the materials encountered – reference should be made to Section 5.13 for further details. These correspond with the published general range of values in the UK, as indicated in Figure 8.1, and alongside the general range of values anticipated for the individual materials.

Figure 8.1: Range of Thermal Conductivity Values for Selected UK Strata



Source: Taken from Site Investigation for Energy Structures, [redacted] 24th April 2017, Quarterly Journal of Engineering Geology

8.3 Converter Station and Substation Connection

The Converter Station and areas of the Friston substation connection are predominantly anticipated to encounter the Diamicton. At the substation connection, areas of Sand and Gravel are anticipated, with the Crag Group likely to be found at depth.

8.3.1 Foundations

Information presented for the Converter Station from engineering logs, in-situ and laboratory testing suggests that the Diamicton increases in strength with depth, with undrained shear strengths in the order of 75kPa anticipated within the top few metres.

The Diamicton is likely to be suitable as a founding medium utilising shallow pad and/or strip footings, dependent on the loads of the structures. It is possible that localised granular materials may be present around foundation level and these may be water bearing. Care will be required to assess the interface of materials of different engineering behaviour (i.e. sand / clay).

Larger raft foundations or foundations with a stricter settlement tolerance (e.g. <10 – 25mm) are anticipated to require a bespoke assessment at the next design stage, and could potentially require a deep foundation solution (such as piles) dependent on the structural loads and sensitivity to differential movement. It is recommended that detailed assessment of stiffness properties of the soils is investigated at the next design stage to inform the most suitable foundation solution.

Caution should also be exercised where foundations may span boundaries between areas of cut and areas of fill, due to potential for differential settlement along this boundary.

8.3.2 Earthworks

An element of cut and fill is required at the Converter Station given the level differences across the site. It is likely that much of the excavated material will be within the upper zone of the Diamicton close to surface. The material near-surface was indicated to display a larger range in plasticity behaviour, though was not shown to display significant softening compared to material at depth.

Earthworks testing, summarised in Section 5.6.1.6, suggests the material is reasonably variable though is likely to be suitable for re-use. This could require an element of either wetting by addition of water, or drying by aeration (during drier weather) to achieve suitable compaction at 95% maximum dry density. If earthworks are required between autumn and spring, addition of lime may assist in reducing materials moisture content, however this would require additional earthworks assessments to ensure the soil does not experience adverse reactions to the addition of lime, including for example swelling. It is recommended that further testing is undertaken at the next design stage to determine suitability of material for treatment for example through the addition of lime and/or cement.

The different treatments required are due to the potential range in engineering behaviour and range of potential optimum moisture contents observed, which vary between 14 – 21%, and elsewhere may be lower where a greater granular content is present in the material (down to c. 11%).

In addition, consideration should be given to the carbonate content of the material, which can lead to re-cementation on compaction and rapid drying between excavation and deposition. This may result in material being placed dry of its optimum moisture content, and a poorer compaction being achieved. Engagement of an earthworks Contractor with experience managing this material during earthworks would be beneficial.

8.4 Unsuitable material

Any unsuitable material encountered, including Made Ground or Alluvium, not considered to be suitable for re-use due to its potential variable properties and organic content, where encountered should be excavated and replaced with a suitable compacted granular engineered fill.

8.5 Pavements

Pavements are required to be constructed to form the permanent access roads, providing suitable formation for areas of proposed construction compounds along the length of the project as well as temporary haul roads which are envisaged along the length of the cable route to assist with its construction.

From review of laboratory and in-situ testing information, the following California Bearing Ratio’s are considered to be appropriate for the current level of design, dependent on the materials which are encountered:

- The Diamicton is likely to achieve a long-term equilibrium CBR of 3% based on its engineering properties. It is possible this could locally be greater, however due to the variability in the material this value has been selected.
- The Sand and Gravel is likely to achieve a long-term equilibrium CBR of 5% based on in-situ and laboratory testing. Laboratory testing could suggest that CBR values of up to 20% could be achievable, however results of in-situ testing appear to indicate lower CBRs in several instances over the likely depth of pavements.

- There remains the potential for localised soft and/or loose spots to be present below the above design CBRs, and where encountered these shall require removal and replacement and/or improvement.
- In areas where Alluvium is encountered, it is envisaged that a form of ground improvement shall be required for the permanent access road to cross the River Fromus. This could form, for example, a dig and replace solution dependent on the depth of material. Reference should be made to Section 8.7 for further information.

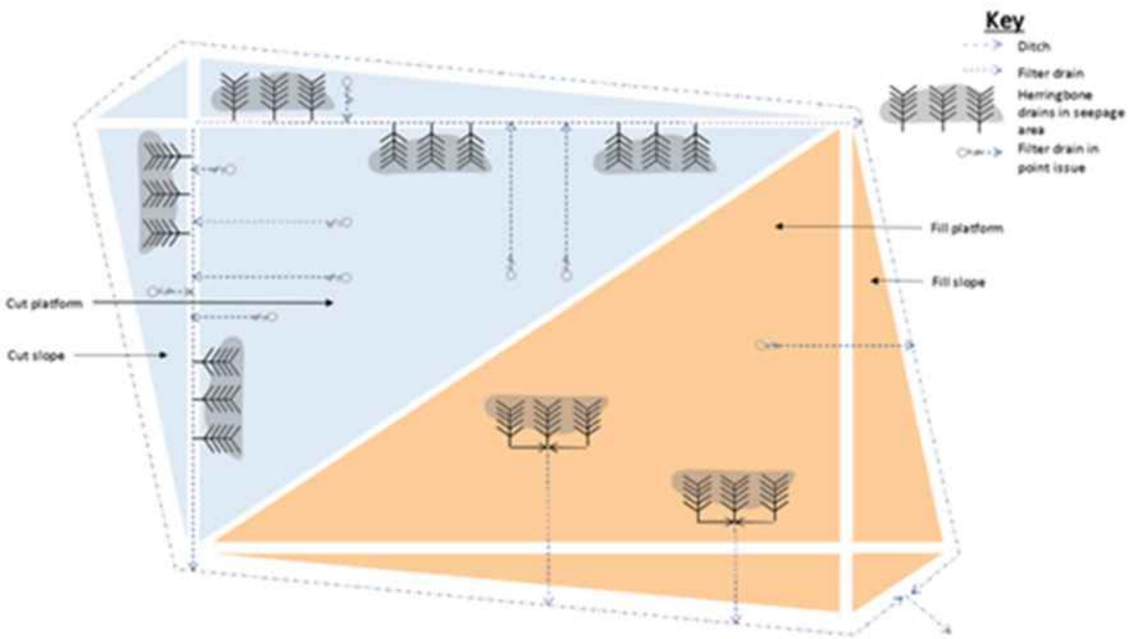
8.6 Drainage

8.6.1 Earthworks drainage

During earthworks, drainage shall be required in order to control surface run-off and protect excavations and formation from adverse weather during construction (this could reduce the quantity of re-usable material and require additional treatment).

The Diamicton can contain granular, water bearing beds and where encountered during the cut platform or areas of foundations these may require drainage, therefore the design should provide consideration for these such as filter drains or herringbone drainage where required. An indicative sketch of measures for managing these are presented in Figure 8.2.

Figure 8.2: Indicative Measures for Managing Run-off, Seepage and Formation Softening



8.6.2 Attenuation and infiltration ponds

A series of attenuation and infiltration ponds are proposed along the scheme, as detailed on the design drawings within Appendix A.

Reference should be made to Section 5.10.2 which summarises the results of infiltration testing undertaken during the GI, including tests undertaken as part of the SPR investigation to inform infiltration pond design at the Friston substation connection.

Permanent drainage is not considered to be feasible where the Diamicton is present, and these areas generally correlate with the proposed attenuation ponds. However, where the Diamicton is thin and overlies the Sand and Gravel, or where the Sand and Gravel is recorded at surface, this is considered a potentially suitable medium for infiltration drainage, including where the permanent infiltration pond is proposed in vicinity of Friston Substation. Reference should be made to the results presented in Section 5.10.2 for further information, and to the GQRA report (SEAL-MMD-SEAL-ENG-REP-0690) for potential contaminated land influences related to infiltration.

8.7 River Fromus crossing

The current proposed design for the permanent access route to the Converter Station includes for a bridge crossing with associated approach embankments over the River Fromus, which are anticipated to be up to a maximum of c.4.7m high. This section summarises potential design considerations for this feature.

It is likely that some form of ground improvement would be required for the proposed permanent access road for the Converter Station, where very loose to loose sands / soft clays or sandy silts are recorded. Various techniques of ground improvement could be suitable for the permanent access route to address the risk associated with potential large long-term settlements and poor bearing capacity of the Alluvium.

The thickness of the Alluvium was recorded in the preliminary GI of up to 2.3m, however due to access restrictions at the time of GI it is possible it may be encountered in greater thickness towards the river channel. It will be key to reduce potential settlements associated with constructing embankments over Alluvium. The Alluvium may represent a possible long-term settlement risk as well as a zone of poor bearing capacity for the embankment. It is likely that the underlying Crag Group, which consists of very dense sands, would form a suitable founding medium for transferring loads associated with the embankment to depth.

It is recommended that options for ground improvement are investigated further following development of design, including (but not limited to) examples such as:

- Dig and replace
- Vibro-compaction / replacement or soil mixing
- Piles
- Geo-grid reinforcement / load transfer platform
- Potential mixture of the above solutions

In addition, due to the shallow groundwater table dewatering may be required should any excavations be needed and these are envisaged to require support.

The foundations for the bridge structure are anticipated to require a piled solution based on the expected ground conditions. The Crag Group forms a deposit of significant thickness of approximately 14.5 – 16.2m (present to c. –9.5 to -10m AOD) is anticipated to form a suitable founding medium for piled foundations. The exact requirements should be reviewed during the detailed design stage.

9 Geotechnical risk register

Table 9.4 details the Geotechnical Risk Register for the project. The risks associated with other aspects of the scheme, such as such as procedures and contractual and strategic issues are not dealt with here and the scheme risk register should be consulted for information on these elements.

The Geotechnical Risk Register should be considered as a live document and updated throughout the course of the scheme. It is incumbent on all parties involved in the scheme to advise the other members when the risks change.

Various threats are identified, and the potential consequences of these occurring are described. The risk is derived by considering the severity and likelihood for each threat and opportunity. Both the severity and likelihood have been assessed using a scale of 1 to 5, corresponding to “Minor” to “Catastrophic” for severity and “Extremely unlikely” to “Almost certain” for likelihood. These ratings are summarised in Table 9.1 and Table 9.2, with the risk classification summarised in Table 9.3.

Table 9.1: Risk level matrix

Likelihood		Severity				
		1	**2**	**3**	**4**	**5**
		Minor	**Moderate**	**Serious**	**Major**	**Catastrophic**
1	**Extremely unlikely**	1	2	3	4	5
2	**Unlikely**	2	4	6	8	10
3	**Likely**	3	6	9	12	15
4	**Extremely likely**	4	8	12	16	20
5	**Almost certain**	5	10	15	20	25

Table 9.2: Hazard severity table

Potential severity of harm occurring		
1	**Minor**	Minor damage or loss – (no human injury)
2	**Moderate**	Moderate damage or loss – (Slight injury or illness)
3	**Serious**	Substantial damage or loss – (Serious injury or illness)
4	**Major**	Major damage or loss – (Fatal injury)
5	**Catastrophic**	Catastrophic loss or damage – (Multiple Fatalities)

Table 9.3: Risk classification table

Risk classification	
Low (1 – 8)	Ensure assumed control measures are maintained and reviewed as necessary.
Medium (9 – 19)	Additional control measures needed to reduce risk rating to a level that is equivalent to a test of “reasonably required” for.
High (20 – 25)	Activity not permitted. Hazard to be avoided or risk to be reduced to tolerable level.

Ground investigation can help to mitigate ground and groundwater risks; however, these risks cannot be eliminated. Ground investigations by their nature can only investigate and monitor a small part of the sub-surface conditions for a limited duration. Conditions on site identified during construction could reveal ground conditions that could not have been taken into account from the results of the ground investigation.

It is recommended that adequate and appropriate supervision must be provided during construction to assess the ground conditions encountered and interpret the results of the site testing. When appropriate this supervision during construction should be undertaken by a suitably experienced and qualified Engineering Geologist / Geotechnical Engineer.

Table 9.4 highlights the potential hazards that could be encountered during the site investigation and/or construction. The consequence of the hazard is outlined, and a score is given for the impact and likelihood of this hazard, giving an overall risk, which is categorised as either a cost, time, environment or health and safety risk. From this, potential control measures are stated to alleviate the hazard, leading to a rescoring of the impact and likelihood, resulting in a residual risk.

Table 9.4: Geotechnical Risk Register

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
1. Topsoil	Topsoil encountered across majority of site footprint at surface Potential for contamination (see 12)	3	3	9	Undertake topsoil resource survey to determine suitability for re-use where required. Best practice during construction, including segregation of materials during excavation	1	3	3
2. Made Ground	Made Ground may locally be encountered, particularly in vicinity of developed areas. Limited Made Ground was recorded on site-specific GI though may be reworked from natural deposits such as Alluvium and Lowestoft Formation and be variable in its nature. Potential for Made Ground to be unacceptable for re-use and require disposal / remediation. Potential for groundwater in the deposit to be contaminated (see 12, 13) Risk of buried known / unknowable obstructions to be encountered during construction	3	3	9	Early consultation required with regulatory bodies. Construction strategy to be in place by Contractor to eliminate risk of contaminant migrations Obtain as-built information, GPR surveys and confirm locations of any known obstructions, or demolish in advance of construction works. Mitigation plan to be in place for dealing with unexpected obstructions.	2	3	6
3. Alluvium [In proximity of River Fromus only]	Alluvium was encountered as very loose to loose clayey sands, soft sandy silts or clays. Potential to encounter very soft to soft normally consolidated organic clays and beds of Peat in areas not covered by GI survey. Low bearing capacity, and high compressibility. Excessive total / differential settlement of access haul roads due to potential presence of organic materials Variable permeability and potential excavation instability Secondary A Aquifer – potential for groundwater contamination and pathways for contamination migration (see 11) Shallow groundwater likely to be present associated with River Fromus. Unlikely to be suitable for material re-use, except for landscape fill and is likely to require improvement / treatment or disposal off site where present. May be aggressive to buried concrete and infrastructure, where material containing presence of organic materials is encountered (see 15).	4	4	16	Contractor to carry out temporary works design including design of any necessary excavation support and stability analysis as well as control of groundwater inflows. Undertake additional investigation at the detailed design stage to determine variability and thickness of Alluvium to inform embankment design for River Fromus crossing, including any ground improvement which may be required.	2	4	8
4. Tidal Flat Deposits	Encountered in vicinity of the Red Penguin HDD alignment near surface as very soft to soft organic clays and Peat.	3	2	6	Red Penguin to consider potential risks with the proposed HDD alignment. It is envisaged that the alignment will pass beneath this material, therefore no	2	2	4

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
	Highly compressible, low bearing capacity Aggressive to buried concrete and infrastructure Variable permeability				additional mitigations may be required (subject to confirmation by Red Penguin).			
5. Marine Beach Deposits	Encountered in vicinity of the Red Penguin HDD alignment near surface as well graded gravels Variable permeability	2	2	4	Red Penguin to consider potential risks with the proposed HDD alignment. It is envisaged that the alignment will pass beneath this material, therefore no additional mitigations may be required (subject to confirmation by Red Penguin).	1	2	2
6. Lowestoft Formation (Diamicton)	Variable thickness of weathering zone at the top of the unit. Reduced bearing capacity, variable total / differential settlement of any shallow foundations, temporary haul roads and cable route. Potential for shrink swell behaviour / moisture sensitivity, dependent on behaviour. Potential obstructions – cobbles of flint, potential to encounter boulders (though none were recorded during the GI) Variable permeability, including presence of water bearing granular beds may lead to instability during excavations and requirement for dewatering Likely to be susceptible to frost-heave, particularly due to high Chalk content of the material Poor infiltration characteristics of near-surface materials meaning SuDS drainage is unlikely to be feasible Secondary Undifferentiated aquifer Fill derived from this material may not meet air voids requirements if dry due to presence of Chalk (this can re-cement and make it difficult to re-work)	3	4	12	Settlement analysis to be undertaken at detailed design stage. Soft spots to be removed and replaced with an appropriate granular engineered fill. Earthworks to be undertaken with good workmanship, and material to be protected from moisture ingress. Contractor to carry out temporary works design including design of any necessary excavation support and stability analysis. Contractor to allow for control of groundwater inflows. Drainage design to consider poor infiltration characteristics of this material.	2	4	8
7. Lowestoft Formation (Sand and Gravel)	Deposits may be of variable density, composition and thickness, presenting a risk of differential settlement, including potential presence of cohesive beds (clays, silts). Potential for shallow groundwater and excavation instability Secondary A Aquifer designation, potential for groundwater contamination and pathways for contamination migration (see 11) Potential for presence of unmapped sand and gravel pits in this material (poorly compacted backfill, high total / differential settlements and poor bearing capacity)	3	3	9	Contractor to carry out temporary works design including design of any necessary excavation support and stability analysis. Contractor to allow for control of groundwater inflows using a cut-off and suitable drainage. Carry out pre-conditions surveys if close to existing structures Excavate and replace unsuitable material with compacted suitable material.	2	3	6

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
8. Crag Formation and Chillesford Church Sand Member	Difficulty in excavating where present (e.g. if cemented sand / harder layers are encountered) Potential for mapped (and unmapped) historical excavations e.g. Crag Pits. Potential for poorly controlled backfill, low bearing capacity and large total / differential settlements where present. Principal Aquifer – potential for works to contaminate the aquifer if not adequately controlled. Excavation instability Potential for shallow groundwater, dewatering may be required	2	3	6	Consider methods of groundwater cut-off to avoid the need to de-water (where required). Contractor to carry out temporary works design including design of any necessary excavation support and stability analysis.. Carry out pre-conditions surveys if close to existing structures. Develop construction strategy to eliminate the risk of contaminating the aquifer.	1`	3	3
9. Coralline Crag Formation	Cemented sand and shells, may be abrasive to machinery Principal Aquifer – potential for works to contaminate the aquifer if not adequately controlled. Excavation instability Potential for shallow groundwater, dewatering may be required of trench excavations or trenchless launch / reception pits	3	3	9	Red Penguin to consider geotechnical properties of material in vicinity of HDD alignment.	2	3	6
10. London Clay Formation	Stiff to very stiff overconsolidated clay, likely to be present at depth across the wider area. May be encountered in the Red Penguin HDD alignment. Variable weathering zone and engineering properties Likely to be aggressive to below ground infrastructure and concrete (see 15)	3	2	6	Unlikely to be encountered as part of on-shore scheme. Red Penguin to consider geotechnical properties of material in vicinity of HDD alignment.	2	2	4
11. Groundwater	Groundwater depth varies across the site (see Section 6.11). Potential for perched groundwater within some deposits (e.g. Diamicton, see 5) Groundwater ingress may cause excavation instability. The majority of the site lies within a Source Protection Zone (SPZ) – Outer Catchment. May dictate type of suitable ground improvement for River Fromus crossing (see 26). Groundwater in vicinity of Red Penguin HDD area indicated to be tidally influenced.	3	4	12	Best practice during construction including following design drawings and suitable method statements, ensuring correct use of temporary works when necessary and highlighting any hazards which may arise. Ensure temporary works design considers the ground conditions, in particular if groundwater is encountered during excavations Refer to 12 for protection of aquifers.	3	2	6
12. Groundwater contamination	The GQRA report (see Section 7) has been prepared alongside this GIR. This identified the risk to the water environment and groundwater (predominantly the Lowestoft Formation and Crag Group) to be very low to low.	3	2	6	Should any dewatering of excavations be required, water may require to be disposed of off site. Consultation should be undertaken with the Environment Agency should this be required.	3	1	3

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
					Reference should be made to the recommendations within the GQRA for further information (see Section 7). Any below-ground infrastructure and services should be appropriately designed to endure contact with any contaminants in groundwater.			
13. Soil contamination	The GQRA report (see Section 7) has been prepared alongside this GIR. This identified pollutant linkages at the site as low to very low risk, with no visual or olfactory evidence of potential contamination at the site. The risk to human health is considered to be low to very low.	3	3	9	A robust CPP and CEMP should be put in place to ensure no undue risks are posed to human health and controlled waters receptors during the construction phase. In the event that unexpected contamination is found when carrying out the proposed development, such as oily, odorous, brightly coloured or fibrous material in soils, works are to cease and the local planning authority are to be advised. The re-use of this material including earthworks may need to be covered by a CL:AIRE Materials Management Plan, or other suitable permitting regime. Additional risk assessment may be required dependent on the quantity of material to be re-used. A waste Contractor should be contacted to discuss appropriate soil disposal options should soils require removal from site. Reference should be made to the GQRA (see Section 7) for full details on contaminated land related recommendations.	3	1	3
14. Unexploded Ordnance	The detailed UXO risk assessments undertaken for the site indicated a risk level ranging between medium to high. Potential to encounter UXO during construction works and excavations. Reference should be made to the reports for further information: ● Safelane Global, Detailed Unexploded Ordnance Risk Assessment, Friston 1, Report reference: 9758-1 RA, June 2023. ● Safelane Global, Detailed Unexploded Ordnance Risk Assessment, Sea Link Outline, Suffolk - Revision, Report reference: 9758-2 RA, June 2023.	5	3	15	Implementation of mitigation measures recommended as detailed in the Detailed UXO Assessment reports. Adopt best practice, due skill and care in executing ground investigation and in-ground construction activities	5	2	10
15. Aggressive ground conditions	Potentially high levels of sulphate within the ground. This can lead to degradation of concrete strength and quality. Soil and groundwater samples were tested and reported in Section 8.3	3	4	12	Ensure any concrete on site is designed in accordance with measured levels of sulphates within the soil and groundwater, and the appropriate class is taken based on the design activity. See Sections 6.12 and 8.3 for further detail.	3	2	6
16. Ground gases and vapours	Potential for gases to accumulate in confined space, impacting health of workers. Potential gas sources identified at the site include infilled pits and any Made Ground / Alluvium.	4	1	4	Refer to no.12.	4	1	4

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
	The derived ground gas Characteristic Situation (CS) for the area, based on CIRIA C665 guidance, was CS-1, very low risk (see GQRA in Section 7 for further information)							
17. Radon	An exposure to elevate radon levels overtime may lead to disease. The site is in an area where <1% of dwellings exceed the Radon Action Level – no radon protection measures are required as reported in the Groundsure report	2	2	4	No radon protective measures are necessary in the construction of new dwellings or extensions. More information can be found at www.ukradon.org	2	1	2
18. Flooding	Localised areas along the site are located within Flood Zone 2 and 3, including areas along drainage ditches and adjacent to the River Fromus.	4	3	12	Undertake flood risk assessment and consider potential for flooding as part of any design of elements at the River Fromus crossing	4	2	8
19. Ecology	Potential damage and impacts on important habitats, protected / notable species or non-statutory designated sites, as well as delays to construction. Existing infrastructure/ environmental features/ land access issues constrain the working area available resulting in reduced efficiency/ buildability and increase in safety hazards. Reference should be made to information provided by National Grid's Environmental Consultant.	3	3	9	Reference should be made to National Grid's Environmental Consultant's reporting and relevant information to inform detailed design and construction processes, including any required mitigation measures for the sites ecological constraints.	3	2	6
20. Archaeology	Programme delays if statutory obligations to investigate/ survey are not fulfilled prior to commencement of construction Potential areas of archaeological importance noted across the scheme.	2	3	6	Any potential archaeological constraints which may influence construction should be assessed in detail during the detailed design stage. It is understood that separate archaeological surveys are being carried out to assess this in further detail.	2	1	2
21. Design elements – Cable route	Lowestoft Formation Diamicton or Sand and Gravel is likely to be encountered – refer to no 5 and 6 for further detail. Refer to 24 for earthworks and 27 for pavements. Dependent on structural loads, deeper foundations such as piles may be required for some elements such as pylons. Potential for groundwater inflow e.g. perched water tables may lead to local instability and obstructions with the Diamicton.	2	3	6	Undertake ground investigation at the next design stage to inform detailed design development Formation should be inspected, and any localised soft and/or loose spots removed and replaced or improved. Best practice during construction including following design drawings and suitable method statements, ensuring correct use of temporary works when necessary and highlighting any hazards which may arise. Concrete to be designed in accordance with BRE SD:1 (see 15)	1	3	3
22. Design elements – Converter Station	Raft foundation and/or piles may be required dependent on structural loads and structural settlement tolerances Potential for localised granular water bearing beds to be encountered in the Diamicton (refer to 5) Potential for aggressive ground – see 14	3	3	9	Undertake ground investigation at the next design stage to inform detailed design development Formation should be inspected, and any localised soft and/or loose spots removed and replaced or improved.	3	2	6

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
					Best practice during construction including following design drawings and suitable method statements, ensuring correct use of temporary works when necessary and highlighting any hazards which may arise. Concrete to be designed in accordance with BRE SD:1 (see 15)			
23. HDD sections	HDD may encounter both clay and sand / cemented sands, potentially with hard bands (see 9). Potential for variable conditions including localised loose or running sands. Groundwater ingress into launch / reception pits leading to excavation instability	4	3	12	Off-shore connection HDD is the responsibility of Red Penguin. Red Penguin to consider geotechnical properties of material in vicinity of HDD alignment and appropriate methods of construction based on the ground conditions.	4	2	8
24. Earthworks	Volumes of re-usable material and material requiring any kind of treatment to be assessed at the detailed design stage. Lowestoft Formation Diamicton and Sand and Gravel are anticipated to be predominant sources of site-won material and most of the material is likely to be suitable for re-use, dependent on its required end-use (see high-level assessments presented in Section 5 and Section 9). Treatment such as wetting or drying is envisaged to be required to ensure appropriate level of compaction	3	3	9	Make sufficient allowance for unsuitable material in the cut to fill design Prepare earthworks specification including classification testing prior to and during site works to ensure material is suitable for re-use. Segregation of materials during construction. Earthworks to be undertaken with good workmanship and to avoid inclement weather. Undertake further assessment at the next design stage to determine suitability for site-won material for treatment such as lime and/or cement stabilisation where required).	3	2	6
25. Below ground and overhead# utilities (including known and unknown / unknowable)	Unexpected delay and additional measures to repair and divert unknown utilities. Temporary loss of utility. Possible injury or death during intrusive works. Revision to proposed alignment/ design revision required. Cost and programme implication. Overhead services - space constraint on construction plant access, service strike during ground investigation/ construction works, temporary loss of utility, cost of repair and programme delays	4	3	12	Additional GPR surveys plus mitigation plan for dealing with unplanned utilities. Early liaison to arrange overhead lines to be temporarily switched off during construction activities. All works to be carried out in accordance with HSE Guidance Note GS6: Avoiding Danger from Overhead Power Lines (4th Edition). Due skill and care in executing in-ground activities. Obtain any plans from landowners where relevant.	4	1	4
26. River Fromus crossing	Potential for large long-term settlements associated with construction of approach embankments for bridge structure over Alluvium deposits (see 3) Potential for large differential settlements between structural elements and/or the edge of the Alluvium deposit Potential for impacts on adjacent watercourse during construction. Potential aggressive ground (see 15)	4	4	16	Undertake ground investigation at the next design stage to inform detailed design development including for example settlement analyses, ground improvement and embankment design. Best practice during construction including following design drawings and suitable method statements, ensuring correct use of temporary works when necessary and highlighting any hazards which may arise. Concrete to be designed in accordance with BRE SD:1 (see 15)	4	1	4

Hazard	Consequences	Severity	Likelihood	Risk	Mitigation	Severity	Likelihood	Risk
27. Pavements	Pavements are predominantly likely to encounter the Lowestoft Formation (see 6, 7). Potential presence of localised silts which may have a poor CBR. Potential for soft / loose spots Section 9.5 covers potential CBR values for pavement design. The Diamicton may be susceptible to frost-heave due to Chalk content, as well as being moisture sensitive or subject to shrink / swell.	3	2	6	Remove soft/loose spots and replace with a suitable granular fill, compacted to achieve the required design CBR value. Pavements to be founded below the frost susceptible zone (450mm). Material to be suitability protected from moisture ingress during construction and from inclement weather. Sub-formation only to be exposed immediately prior to construction.	3	1	3
28 Limited GI information	Limited GI undertaken in certain areas of the site – including between Friston substation and Snape Road. Potential for variable ground conditions associated with Lowestoft Formation	3	2	6	Undertake additional investigation at the next design stage in accordance with BS EN 1997-2.	3	1	3
29. Presence of field drains	may lead to seepage into trench excavations. May require diversion or reinstatement.	2	2	4	Obtain any plans from landowners. Contingency allowance for managing damaged field drains and water inflows.	1	2	2

10 Conclusions and Recommendations

This summary contains an overview of the key findings and conclusions of this report. However, no reliance should be placed on any part of this summary without referring to the relevant Sections in the report. Sections within the main body of the report contain information which puts into context the findings that are captured within this summary. The key findings of this report are summarised below.

10.1 Conclusions

10.1.1 Geotechnical

The ground conditions across the site vary, with the site located over lowland glaciated terrain in Suffolk. The dominant strata likely to be encountered are the units of the Lowestoft Formation, with the underlying bedrock of the Crag Group or other units such as Alluvium likely to be found where the terrain is cut by rivers, such as the River Fromus south of Saxmundham.

A series of ground models have been derived for the site based on freely available information and site-specific ground investigation, summarised above in Section 4, 7 and are presented in more detail in Appendix B including their spatial distribution across the site. For further details reference should be made to the relevant Sections in this report.

, and to Section 7.2 which discusses preliminary geotechnical parameters.

Based on information from the preliminary GI undertaken at the site in 2023, a series of ground models have been presented within Appendix B.

A high-level summary of the main strata likely to be encountered are summarised below:

- Made Ground – Made Ground was only locally encountered near-surface, and likely to be reworked from underlying natural materials including Alluvium / Lowestoft Formation.
- Lowestoft Formation – The dominant units encountered across the site were the Diamicton and Sand and Gravel, briefly described below. These are the dominant materials anticipated to be encountered at foundation level for structures or during cable trenching works:
  - Diamicton – generally firm (locally soft) to very stiff slightly sandy slightly to gravelly CLAYs with low cobble content, locally containing greater sand content in the central area of the cable route in vicinity of Snape road
  - Sand and Gravel – generally encountered as slightly to clayey slightly gravelly SAND though in vicinity of Snape Road, sandy SILT and sandy CLAY were also recorded, suggesting potential for local variation of the Silt and Clay sub-member of the Lowestoft Formation
- Crag Group – The bedrock of the Crag was encountered in vicinity of the River Fromus near Saxmundham and at the eastern extent of the scheme at the connection between the terrestrial and marine elements of the project (HDD connection). Elsewhere, this unit was generally present at depth and generally was described as a dense to very dense slightly to gravelly clayey or silty SAND with rare to occasional shell fragments, flasers of dark grey clay or soft silty nodules and locally contained laminated cohesive beds.
- Other deposits were recorded either at depth (such as the London Clay Formation) and are unlikely to be encountered, or are recorded In vicinity of the offshore HDD connection which is the responsibility of Red Penguin, these include Tidal Flat Deposits, Marine Beach Deposits, the Coralline Crag Formation and the London Clay Formation. Reference should be made to information in Section 5 and 7 for further details on these strata.

- A geological section was prepared to help illustrate the ground conditions in vicinity of the proposed Converter Station and associated crossing over the River Fromus, presented in Section 4.
- Groundwater levels were found to vary across the scheme. In vicinity of the Converter Station, groundwater was between c. 7 – 11m AOD, reducing to c. 7m AOD at the River Fromus. Localised seepages and groundwater were noted in granular beds within the Diamicton at greater elevations. Towards the eastern end of the project, groundwater was encountered up to c. 1.5m AOD adjacent to the coast, reflecting tidal variations throughout the monitoring period.
- A series of earthworks relationship tests were undertaken on the Lowestoft Formation (Diamicton and Sand and Gravel). These suggested several different types of earthworks materials may be present dependent on particle grading and engineering behaviour. It is likely the vast majority of material would be suitable for re-use with appropriate treatment including wetting and/or drying, however further assessments will be required prior to construction.
- A series of recommended preliminary design parameters are presented within Section 7, and these are subject to review and development to inform specific design elements, and should any additional ground investigation be undertaken. Consideration should be given to the design task to adapt appropriate parameters
- A geotechnical risk register is presented in Section 9 and highlights the risks that require further mitigation during design and construction. The key risks are thought to include the following:
  - Alluvium and River Fromus crossing – There remains a risk of large long-term total and differential settlement for any elements which may bear onto the Alluvium, including for example the approach embankments for the river crossing and any adjacent areas of pavement.
  - Excavations are likely to require support, due to the variability of the Lowestoft Formation and likely presence of the Sand and Gravel along c. 50% of the cable route.
  - Groundwater is likely to be encountered during construction, either as the permanent groundwater table or perched water tables. This will require consideration during construction and any trenching / excavations.
  - Lithological variability within the Lowestoft Formation should be considered when undertaking cabling works e.g. potential presence of obstructions within the Diamicton. This should be considered when scoping additional investigation, with certain areas of the site not covered by the existing GI information in the western to central area of the cable alignment in vicinity of Friston Substation, over a distance of approximately 3km.
  - Aggressive ground conditions are expected, with lower levels of sulphate noted in Alluvium / Made Ground, the Lowestoft Formation and Crag Group. Elevated levels of sulphate were recorded in the London Clay Formation, though this is not anticipated to be encountered across the on-shore element of the project. Groundwater was noted to be aggressive to concrete and below ground infrastructure at the eastern end of the project as part of the offshore HDD connection, which could potentially be influenced by the saline environment.
  - The potential for unexploded ordnance at the site remains a residual risk, mitigation measures provided within UXO reporting should be adhered to during construction works.

10.1.2 Geo-environmental

Reference should be made to the GQRA report for further details on the geo-environmental conclusions:

- Mott MacDonald Limited, Sea Link FEED, Generic Qualitative Risk Assessment (GQRA) – Friston, May 2024. Document reference: SEAL-MMD-SEAL-ENG-REP-0690.

10.2 Recommendations

The following recommendations are proposed to address the geotechnical risks identified at the site and as detailed in the Geotechnical Risk Register in Section 9:

- It is recommended that additional ground investigation is undertaken at the next design stage to further investigate particular elements including for example earthworks re-use and treatment assessment (such as lime and/or cement stabilisation feasibility), ground improvement, as well as further ground information related to the River Fromus crossing.
- In addition, at the time of undertaking the 2023 ground investigation, certain areas of the site were not accessible during the fieldworks and therefore no GI could be carried out. This includes for example the Friston Substation and its connection to / from the proposed buried cables (covering an area of c. 3km of cable route). The coverage of GI should be reviewed following development of design, and any additional GI undertaken as required.
- Earthworks acceptability and testing of site-won materials should be carried out prior to and during construction, and the requirements of this should be captured within a project earthworks specification.
- If dewatering is required during construction, pumped water may require storage and testing prior to disposal. Reference should be made to the GQRA for further details
- Should any loose/soft material be present at formation or foundation levels, it should be removed and replaced with a suitable granular engineered fill.
- There remains a residual risk of obstructions including for example potential presence of cobbles / boulders within the Lowestoft Formation. These may require mitigation by removal and replacement or by avoiding them where encountered during any trenching works.
- Excavations are likely to require support due to potential for loose / soft materials, and presence of shallow groundwater locally (e.g. River Fromus). Perched water may also be encountered and may result in localised instability which will require remediation.

Reference should be made to the GQRA report for further details on the geo-environmental recommendations (Document reference: SEAL-MMD-SEAL-ENG-REP-0690).

11 References

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- BS 8004:2015. Code of Practice for Foundations.
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- CIRIA R143, 1995. The Standard Penetration Test (SPT): Methods and Use.
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- National Grid, 2023. The Great Grid Upgrade, Sea Link, Project overview document.
- Stroud, M. A., and Butler, F. G. (1978): The Standard Penetration Test and the Engineering Properties of Glacial Materials
- Structural Soils Limited, “On-shore Geotechnical and Geo-environmental Ground Investigation - Factual Report on Ground Investigation. SPR Reference EA1N-GRD-GEO-REP-SSL-000001.,” 2022.
- Structural Soils Limited, “Suffolk Onshore Cable Link, Factual Report on Preliminary Ground Investigation”, Report No: 563835-01 (03), April 2024

Appendices

A. Drawings

Design drawings

The Great Grid Upgrade

Sea Link

Design Drawings

Version A

October 2023

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

Contents

The Great Grid Upgrade

Sea Link

01. Onshore Design Drawings

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

nationalgrid

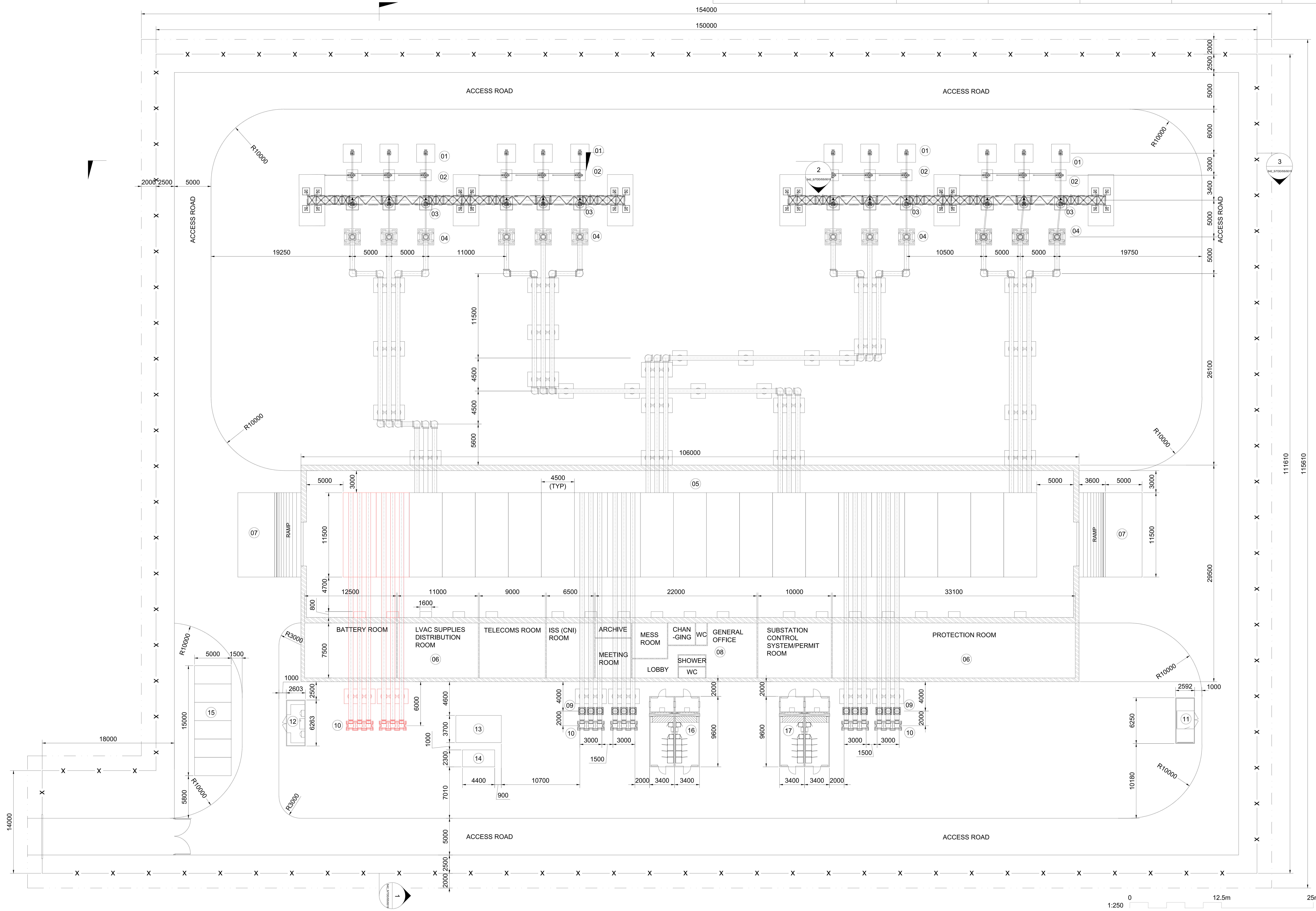
01-01. Friston 400kV Substation

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Friston 400kV Substation	Typical Sea Link works should Friston 400kV GIS substation be developed by others	Suffolk Onshore Scheme	S42_S/TDD/SS/0001
	Typical Friston 400kV GIS substation in scenario where not construction by third party	Suffolk Onshore Scheme	S42_S/TDD/SS/0003
	Typical Friston 400kV GIS substation - elevation drawing	Suffolk Onshore Scheme	S42_S/TDD/SS/0019

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL SEA LINK WORKS SHOULD FRISTON 400kV GIS SUBSTATION BE DEVELOPED BY OTHERS
SHEET 1 OF 1

NOMINAL SYSTEM VOLTAGE	PHASE TO EARTH	PHASE TO PHASE	SAFETY DISTANCE (FROM NATIONAL GRID SAFETY RULES)	DESIGN CLEARANCE FOR SAFETY (VERTICAL) Ds	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL) Dsh	INSULATION HEIGHT Ih
kV	M	M	M	M	M (SEE POINT ii FROM NOTE 6)	M
400	2.8	3.6	3.1	5.5	4.6	2.4



Notes
For statutory consultation purposes only.

1. These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.
2. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
3. Abbreviations
   - AIS - Air Insulated Switchgear
   - CVT - Capacitive Voltage Transformer
   - GIS - Gas Insulated Switchgear
   - ISS - Integrated Security Solutions
   - CNI - Critical National Infrastructure
   - LVAC - Low Voltage Alternating Current
4. Elevation sections relate to S42_S/TDD/SS/0019.

Legend
- EXISTING EQUIPMENT
- NEW EQUIPMENT
- LIMIT OF LAND
- FENCE

ID	DESCRIPTION
01	400kV AIS CVT
02	400kV AIS EARTH SWITCH
03	400kV AIS SURGE ARRESTOR
04	400kV GIS / AIR BUSHING
05	400kV GIS HALL
06	400kV ANNEX BUILDING
07	HARDSTANDING AREA
08	AMENITIES BLOCK
09	400kV GIS SURGE ARRESTOR
10	400kV GIS / CABLE INTERFACE
11	STORAGE
12	WORKSHOP
13	EMERGENCY DIESEL GENERATOR
14	DIESEL TANK
15	PARKING
16	DISTRIBUTED RELAY ROOM (OFTO EA2)
17	DISTRIBUTED RELAY ROOM (OFTO EA1N)

Issue	Date	Remarks	Drawn	Checked	Approved
A	07/09/2023	FINAL	SC	JW	KJ

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER DESIGN DRAWINGS FOR CONSULTATION

TYPICAL SEA LINK WORKS SHOULD FRISTON 400KV GIS SUBSTATION BE DEVELOPED BY OTHERS
SHEET 1 of 1

nationalgrid

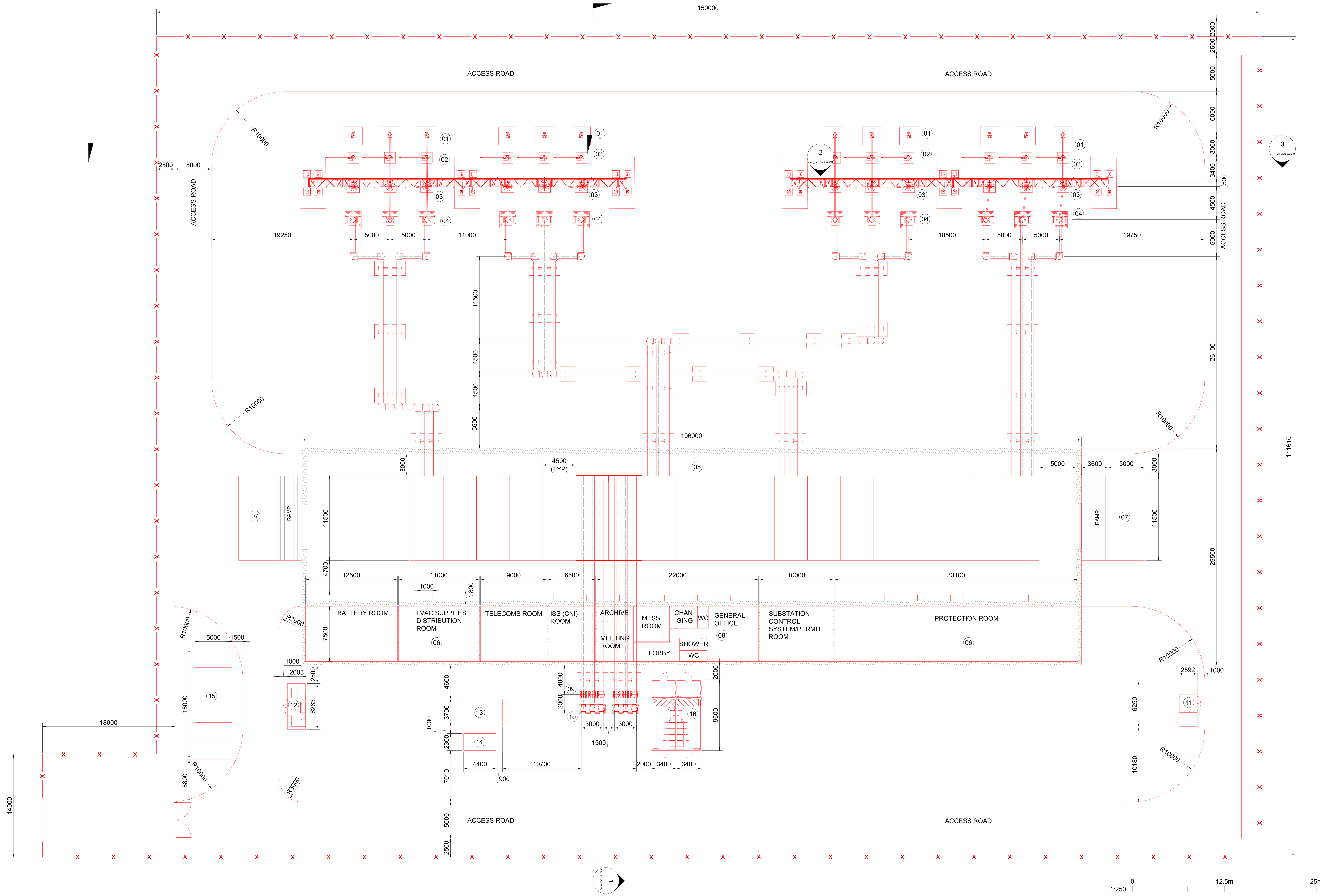
Application Number: EN020026

National Grid Drawing Reference: S42_S/TDD/SS/0001

Scale	Sheet Size	Sheet	Issue
1:250	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY
TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL FRISTON 400kV GIS SUBSTATION IN SCENARIO WHERE NO CONSTRUCTION BY THIRD PARTY
SHEET 1 OF 1

NOMINAL SYSTEM VOLTAGE	PHASE TO EARTH	PHASE TO PHASE	SAFETY DISTANCE (FROM NATIONAL GRID SAFETY RULES)	DESIGN CLEARANCE FOR SAFETY (VERTICAL) Ds	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL) Dsh	INSULATION HEIGHT Ih
kV	M	M	M	M	M (SEE POINT ii FROM NOTE 6)	M
400	2.8	3.6	3.1	5.5	4.6	2.4



Notes

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   - CVT - Capacitive Voltage Transformer
   - GIS - Gas Insulated Switchgear
   - ISS - Integrated Security Solutions
   - CNI - Critical National Infrastructure
   - LVAC - Low Voltage Alternating Current
4. Elevation sections relate to S42_S/TDD/SS/0019.

Legend

- X FENCE
- NEW INFRASTRUCTURE EQUIPMENT

ID	DESCRIPTION
01	400kV AIS CVT
02	400kV AIS EARTH SWITCH
03	400kV AIS SURGE ARRESTOR
04	400kV GIS / AIR BUSHING
05	400kV GIS HALL
06	400kV ANNEX BUILDING
07	HARDSTANDING AREA
08	AMENITIES BLOCK
09	400kV GIS SURGE ARRESTOR
10	400kV GIS / CABLE INTERFACE
11	STORAGE
12	WORKSHOP
13	EMERGENCY DIESEL GENERATOR
14	DIESEL TANK
15	PARKING
16	DISTRIBUTED RELAY ROOM (OFTO EA2)
17	DISTRIBUTED RELAY ROOM (OFTO EA1N)

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER DESIGN DRAWINGS FOR CONSULTATION TYPICAL FRISTON 400kV GIS SUBSTATION IN SCENARIO WHERE NO CONSTRUCTION BY THIRD PARTY
SHEET 1 OF 1

nationalgrid

Application Number: EN020026

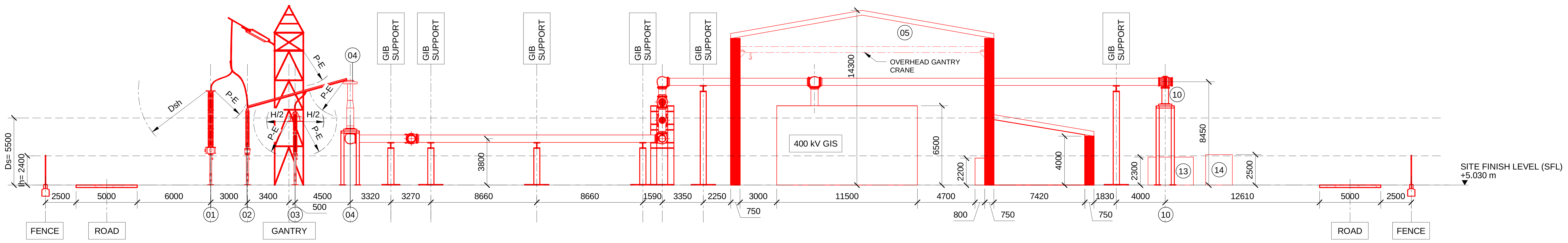
National Grid Drawing Reference: S42_S/TDD/SS/0003

Scale	Sheet Size	Sheet	Issue
1:250	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL FRISTON 400kV GIS SUBSTATION - ELEVATION DRAWING
SHEET 1 of 1

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



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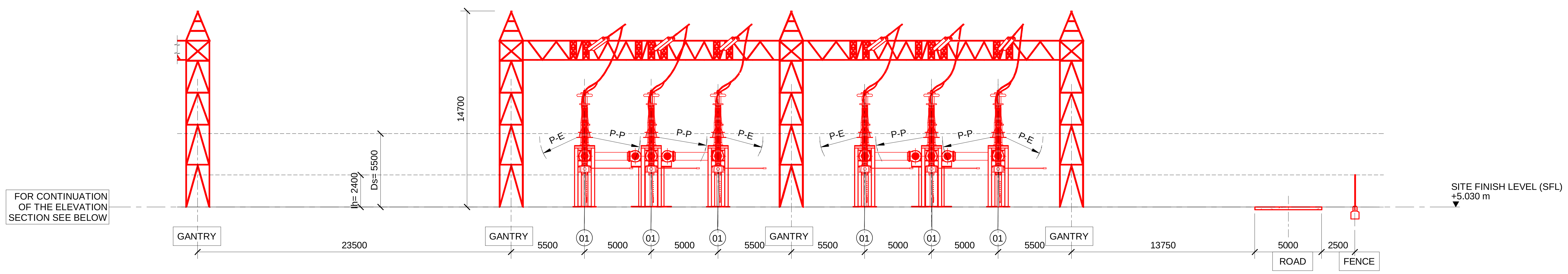

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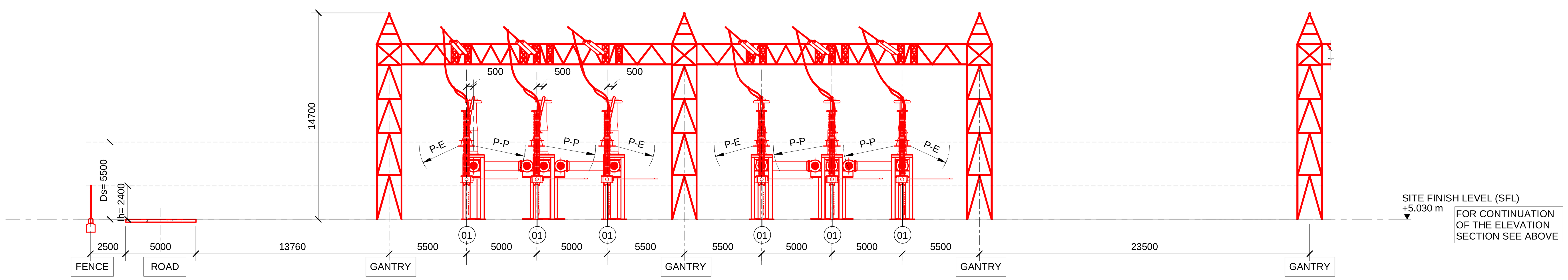

ELEVATION 3
1 : 200

Notes

FOR STATUTORY CONSULTATION PUPOSES ONLY.

1. THESE PLANS SHOW THE DRAFT ORDER LIMITS AND DRAFT CABLE ALIGNMENT AND POTENTIAL PYLON LOCATIONS. DUE TO THE NEED FOR FUTURE FLEXIBILITY, NATIONAL GRID WILL BE APPLYING FOR ORDER LIMITS AND LIMITS OF DEVIATION WITHIN ITS DEVELOPMENT CONSENT ORDER, WITHIN WHICH ANY FINAL ALIGNMENT (INCLUDING PYLON LOCATIONS) WOULD LIE. THEREFORE THE DRAFT CABLE ALIGNMENT AND PYLON LOCATIONS SHOULD BE TREATED AS INDICATIVE ONLY. FURTHER INFORMATION IS PROVIDED IN OUR 'GUIDE TO INTERACTING WITH OUR CONSULTATION PLANS' DOCUMENT.
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3. ABBREVIATION

PLC - POWER LINE CARRIER
AIS - AIR INSULATED SWITCHGEAR
CVT - CAPACITIVE VOLTAGE TRANSFORMER
GIS - GAS INSULATED SWITCHGEAR
PIR - PRE INSERTION RESISTOR
LCC - LOCAL CONTROL CUBICLE
PH - PHASE
GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
05	AMENITIES BUILDING
10	WORKSHOP
13	400 kV HARMONIC FILTER - CURRENT TRANSFORMER
14	400 kV HARMONIC FILTER - CAPACITOR

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL FRISTON 400kV GIS SUBSTATION - ELEVATION DRAWING

SHEET 1 of 1

nationalgrid

Application Number
EN020026

National Grid Drawing Reference
S42_S/TDD/SS/0019

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 1 of 1	A

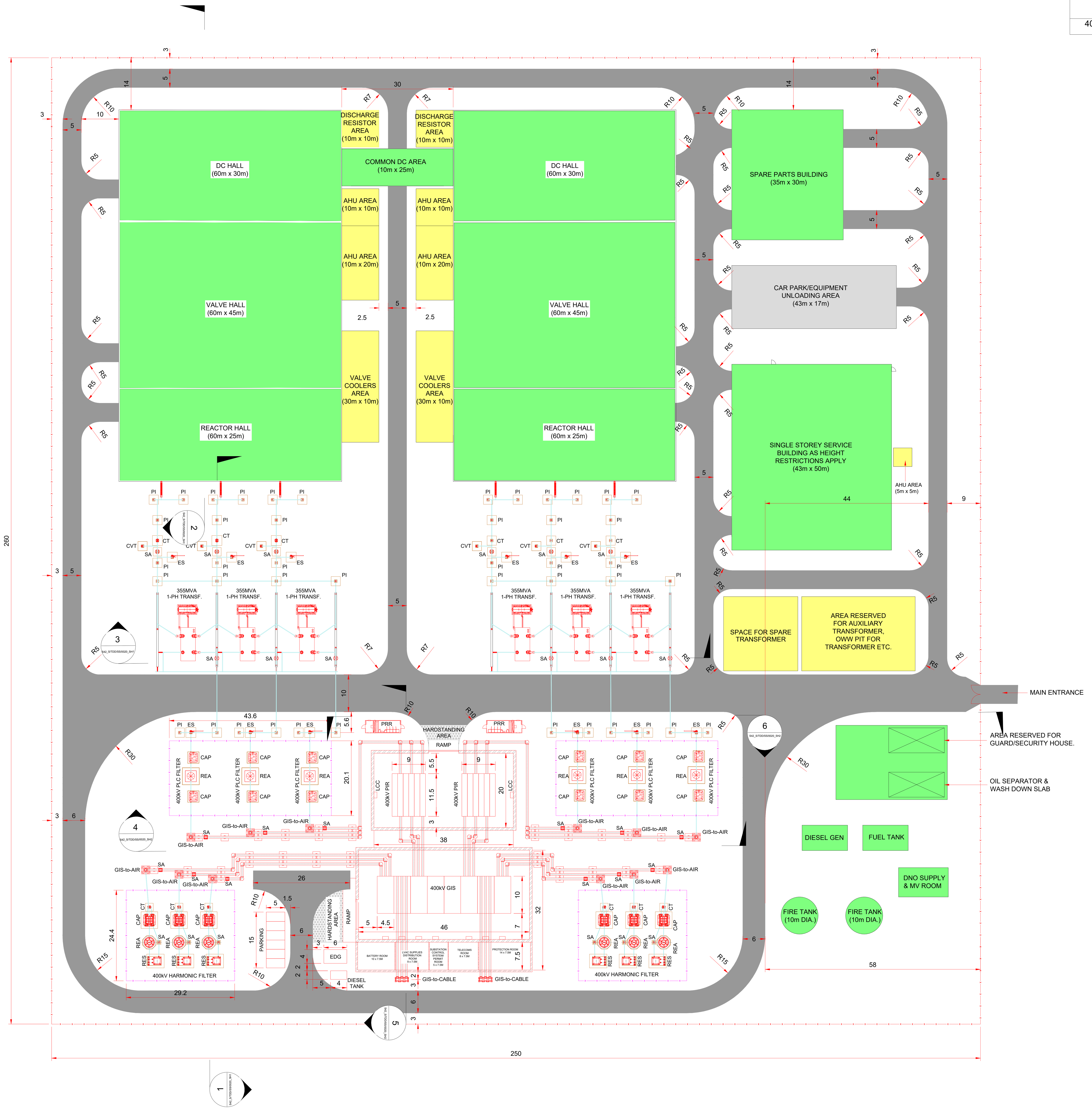
01-02. Saxmundham Converter Station

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Saxmundham Converter Station	Typical Saxmundham converter station layout plan (GIS)	Suffolk Onshore Scheme	S42_S/TDD/SS/0015
	Typical Saxmundham converter station - elevation drawing	Suffolk Onshore Scheme	S42_S/TDD/SS/0020_SH1 S42_S/TDD/SS/0020_SH2

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL SAXMUNDHAM CONVERTER STATION LAYOUT PLAN (GIS)
SHEET 1 of 1

NOMINAL SYSTEM VOLTAGE	PHASE TO EARTH	PHASE TO PHASE	SAFETY DISTANCE (FROM NATIONAL GRID SAFETY RULES)	DESIGN CLEARANCE FOR SAFETY (VERTICAL) Ds	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL) Dsh	INSULATION HEIGHT Ih
kV	M	M	M	M	M (SEE POINT ii FROM NOTE 10)	M
400	2.8	3.6	3.1	5.5	4.6	2.4



Notes
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2. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
3. Abbreviations
   - PIR - Pre-Insertion Resistor
   - CAP - Capacitor
   - RES - Resistor
   - REA - Reactor
   - PI - Post Insulator
   - CT - Current Transformer
   - CVT - Capacitive Voltage Transformer
   - ES - Earth Switch
   - SA - Surge Arrester
   - PRR - Portable Relay Room
   - LCC - Local Control Cubicle
4. Elevation sections relate to S42_S/TDD/SS/0020_SH1 & S42_S/TDD/SS/0020_SH2.

Legend
- PERIMETER FENCE
- INTERNAL FENCE
- BUILDINGS
- EXTERNAL EQUIPMENT AREAS
- CAR PARK

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER DESIGN DRAWINGS FOR CONSULTATION TYPICAL SAXMUNDHAM CONVERTER STATION LAYOUT PLAN (GIS) SHEET 1 of 1

nationalgrid

Application Number
EN020026

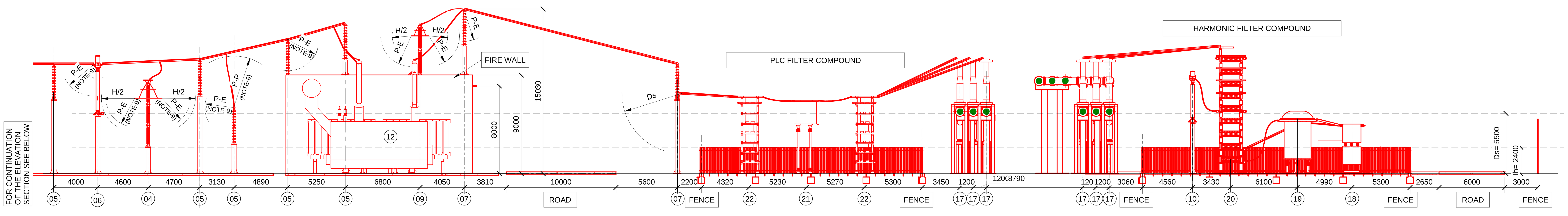
National Grid Drawing Reference
S42_S/TDD/SS/0015

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL SAXMUNDHAM CONVERTER STATION -ELEVATION DRAWING
SHEET 1 OF 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



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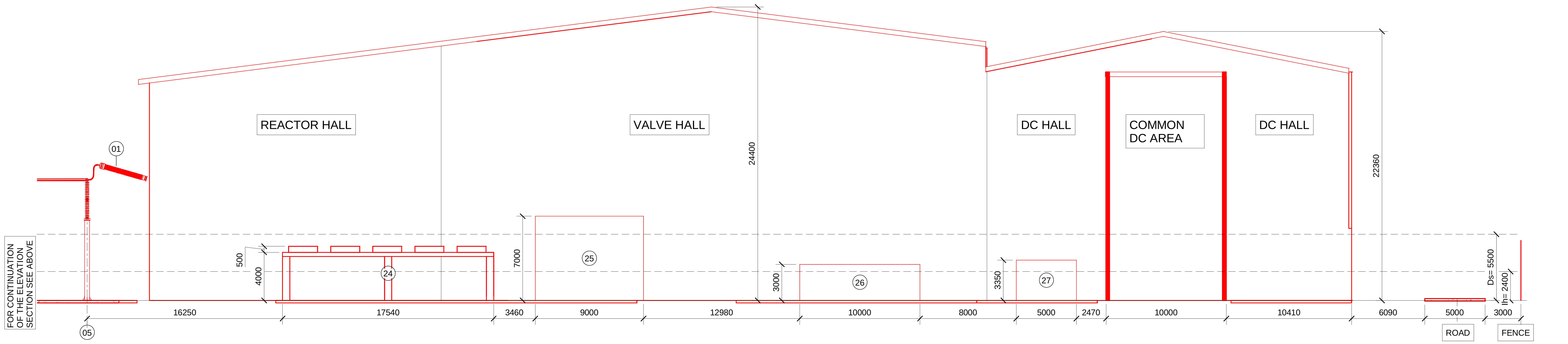

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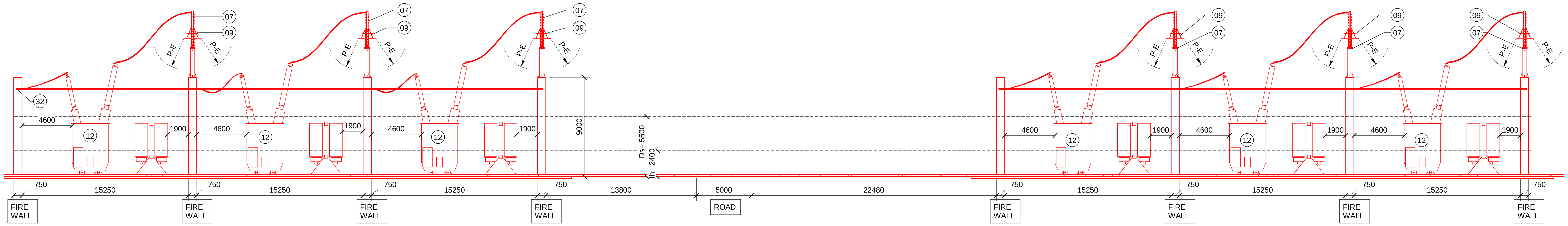

ELEVATION 3
1 : 200

Notes

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GIS - GAS INSULATED SWITCHGEAR
PIR - PRE INSERTION RESISTOR
LCC - LOCAL CONTROL CUBICLE
PH - PHASE
GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	AIR BUSHING WALL PENETRATION
02	550KV AIS CVT
03	550KV AIS EARTH SWITCH
04	550KV AIS SURGE ARRESTOR
05	550KV POST INSULATOR
06	550KV CURRENT TRANSFORMER
07	400 kV AIS POST INSULATOR
08	400 kV AIS EARTH SWITCH
09	400 kV AIS SURGE ARRESTOR
10	400 kV AIS CURRENT TRANSFORMER
11	400 kV GIS
12	400 kV 1PH TRANSFORMER
13	400 kV GIS / CABLE INTERFACE
14	400 kV GIS SURGE ARRESTOR
15	EMERGENCY DIESEL GENERATOR
16	DIESEL TANK
17	400 kV GIS / AIR BUSHING
18	400 kV HARMONIC FILTER - RESISTOR
19	400 kV HARMONIC FILTER - REACTOR
20	400 kV HARMONIC FILTER - CAPACITOR
21	400 kV PLC FILTER - REACTOR
22	400 kV PLC FILTER - CAPACITOR
23	HARMONIC FILTER - SURGE ARRESTOR
24	EXTERNAL FIN FAN COOLER
25	BUILDING FOR PUMP SKID COOLING SYSTEM
26	AHU FOR REACTOR & VALVE HALL BUILDING
27	AHU FOR DC HALL BUILDING
28	PORTABLE RELAY ROOM
29	400 kV PIR
30	400 kV LCC
31	ROLLING SHUTTER DOOR
32	11kV POST INSULATOR

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL SAXMUNDHAM CONVERTER STATION -ELEVATION DRAWING

SHEET 1 OF 2

nationalgrid

Application Number: EN020026

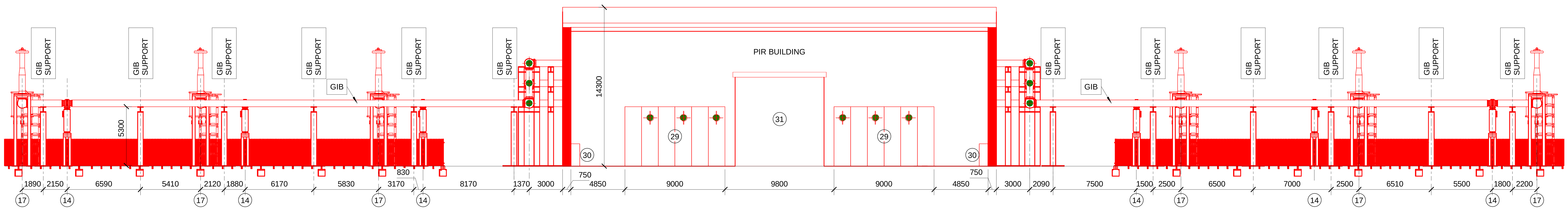
National Grid Drawing Reference: S42_S/TDD/SS/0020

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 1 OF 2	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC(SEA LINK)
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL SAXMUNDHAM CONVERTER STATION -ELEVATION DRAWING
SHEET 2 OF 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



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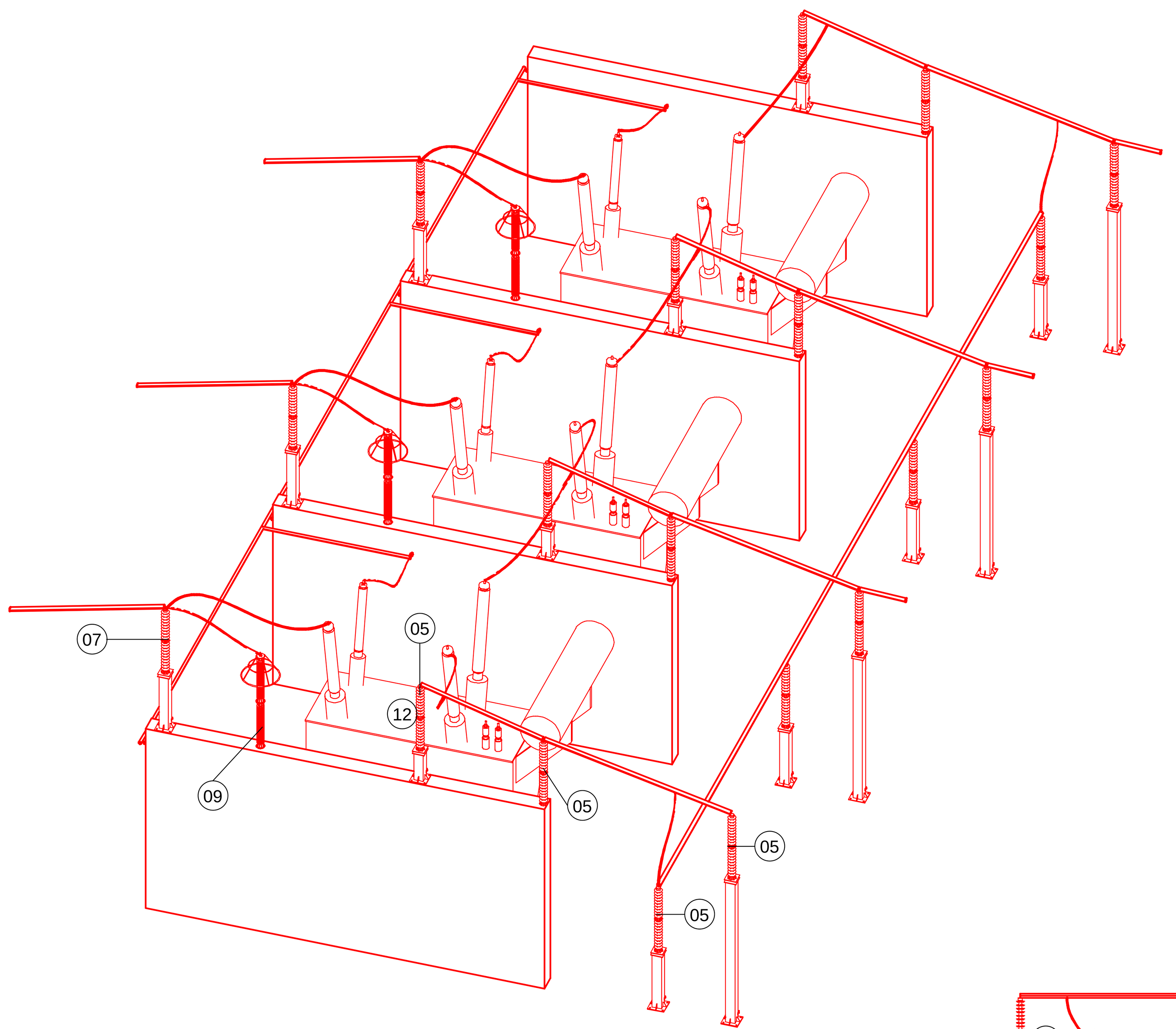
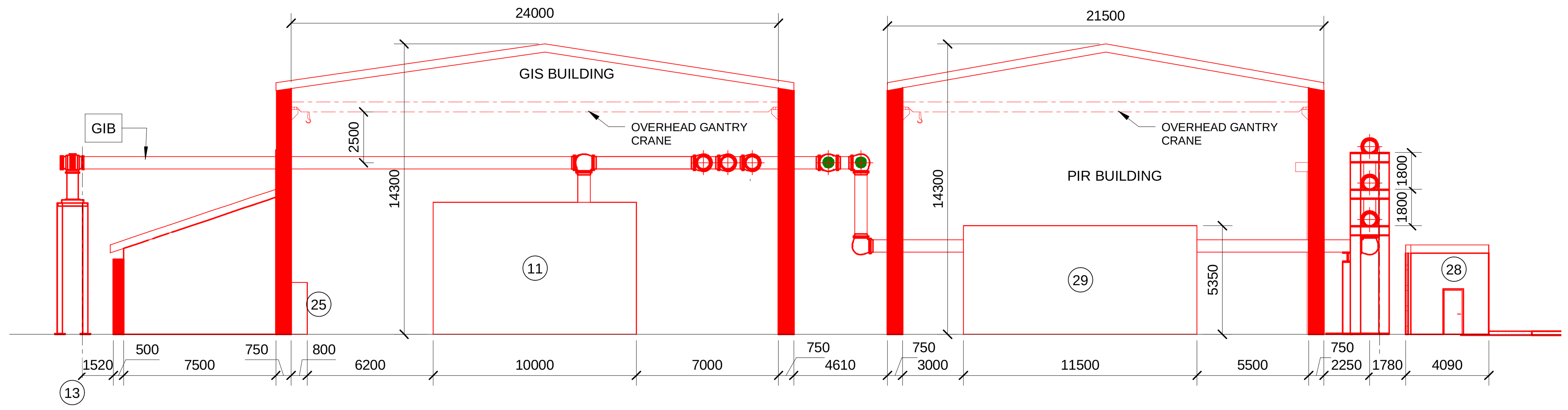


Transformer Area ISO View



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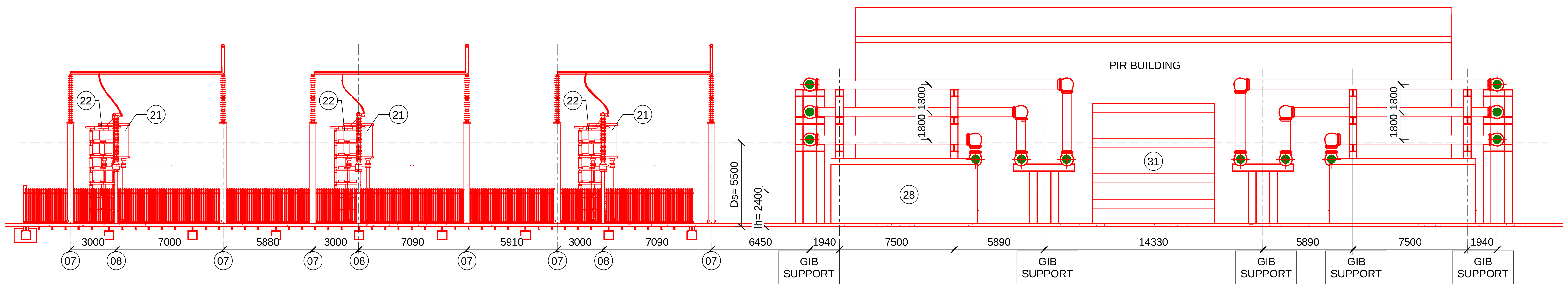

ELEVATION 6
1 : 200

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FOR STATUTORY CONSULTATION PUPOSES ONLY.

1. THESE PLANS SHOW THE DRAFT ORDER LIMITS AND DRAFT CABLE ALIGNMENT AND POTENTIAL PYLON LOCATIONS. DUE TO THE NEED FOR FUTURE FLEXIBILITY, NATIONAL GRID WILL BE APPLYING FOR ORDER LIMITS AND LIMITS OF DEVIATION WITHIN ITS DEVELOPMENT CONSENT ORDER, WITHIN WHICH ANY FINAL ALIGNMENT (INCLUDING PYLON LOCATIONS) WOULD LIE. THEREFORE THE DRAFT CABLE ALIGNMENT AND PYLON LOCATIONS SHOULD BE TREATED AS INDICATIVE ONLY. FURTHER INFORMATION IS PROVIDED IN OUR 'GUIDE TO INTERACTING WITH OUR CONSULTATION PLANS' DOCUMENT.
2. FOR FURTHER INFORMATION ON CONSTRUCTION PLEASE REFER TO THE CONSTRUCTION SECTION OF THE PRELIMINARY ENVIRONMENTAL IMPACT REPORT, VOLUME 1, PART 1, CHAPTER 4.
3. ABBREVIATION
   - PLC - POWER LINE CARRIER
   - AIS - AIR INSULATED SWITCHGEAR
   - CVT - CAPACITIVE VOLTAGE TRANSFORMER
   - GIS - GAS INSULATED SWITCHGEAR
   - PIR - PRE INSERTION RESISTOR
   - LCC - LOCAL CONTROL CUBICLE
   - PH - PHASE
   - GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	AIR BUSHING WALL PENETRATION
02	550KV AIS CVT
03	550KV AIS EARTH SWITCH
04	550KV AIS SURGE ARRESTOR
05	550KV POST INSULATOR
06	550KV CURRENT TRANSFORMER
07	400 kV AIS POST INSULATOR
08	400 kV AIS EARTH SWITCH
09	400 kV AIS SURGE ARRESTOR
10	400 kV AIS CURRENT TRANSFORMER
11	400 kV GIS
12	400 kV 1PH TRANSFORMER
13	400 kV GIS / CABLE INTERFACE
14	400 kV GIS SURGE ARRESTOR
15	EMERGENCY DIESEL GENERATOR
16	DIESEL TANK
17	400 kV GIS / AIR BUSHING
18	400 kV HARMONIC FILTER - RESISTOR
19	400 kV HARMONIC FILTER - REACTOR
20	400 kV HARMONIC FILTER - CAPACITOR
21	400 kV PLC FILTER - REACTOR
22	400 kV PLC FILTER - CAPACITOR
23	HARMONIC FILTER - SURGE ARRESTOR
24	EXTERNAL FIN FAN COOLER
25	BUILDING FOR PUMP SKID COOLING SYSTEM
26	AHU FOR REACTOR & VALVE HALL BUILDING
27	AHU FOR DC HALL BUILDING
28	PORTABLE RELAY ROOM
29	400 kV PIR
30	400 kV LCC
31	ROLLING SHUTTER DOOR
32	11kV POST INSULATOR

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC(SEA LINK)

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL SAXMUNDHAM CONVERTER STATION -ELEVATION DRAWING

SHEET 2 OF 2

nationalgrid

Application Number: EN020026

National Grid Drawing Reference: S42_S/TDD/SS/0020

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 2 OF 2	A

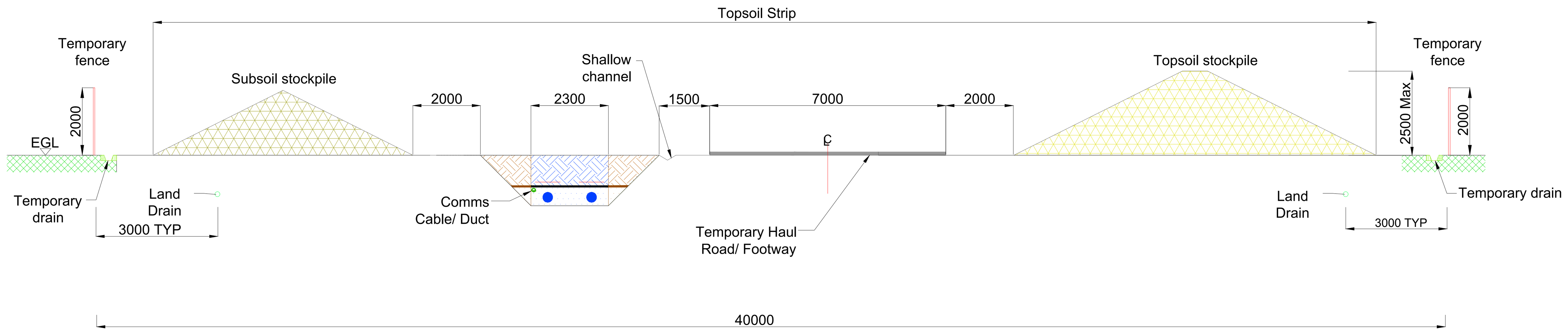
01-03.

Suffolk Only - HVDC & HVAC Cross Sections for Sea Link plus ducts for up to two other projects

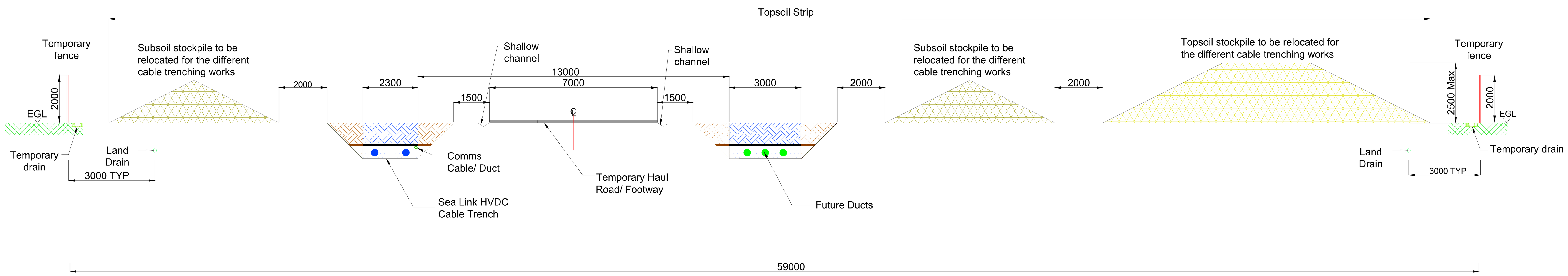
Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Suffolk Only - HVDC & HVAC Cross Sections for Sea Link plus ducts for up to two other projects	Typical HVDC construction area for Sea Link plus ducts for up to two further projects	Suffolk Onshore Scheme	S42_S/TDD/SS/0018
	Typical HVAC construction area for Sea Link plus ducts for up to two further projects	Suffolk Onshore Scheme	S42_S/TDD/SS/0013
	Typical HVAC and HVDC combined construction area for Sea Link plus ducts for up to two further projects	Suffolk Onshore Scheme	S42_S/TDD/SS/0014

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

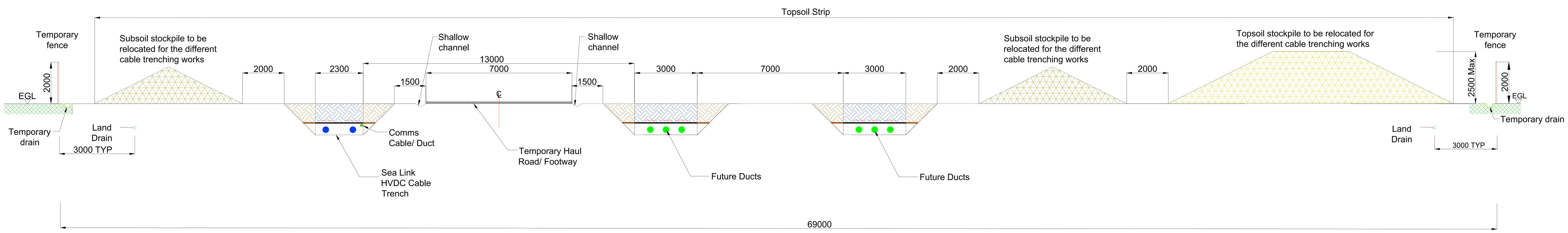
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVDC CONSTRUCTION AREA FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1



Typical HVDC Construction Area - Sea Link
Scale 1:150



Typical HVDC Construction Area - Sea Link + One Further Project
Scale 1:150



Typical HVDC Construction Area - Sea Link + Two Further Projects
Scale 1:150

SCALE BAR (METRES)
1:150 0 7.5m 15m

Notes

For statutory consultation purposes only.

These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVDC CONSTRUCTION AREA FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1

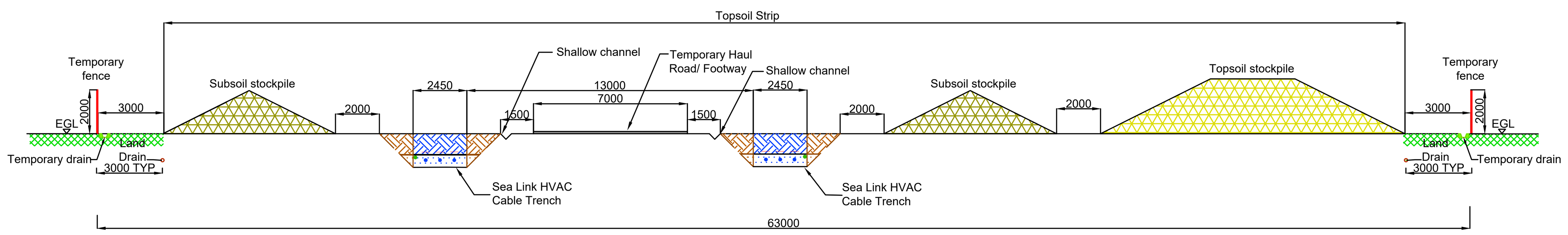
nationalgrid

Application Number
EN020026

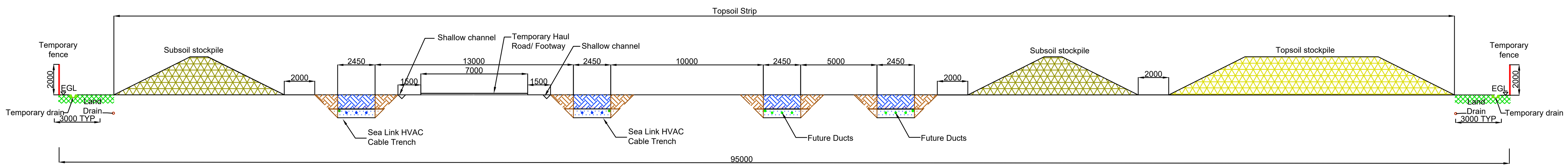
National Grid Drawing Reference
S42_S/TDD/SS/0018

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

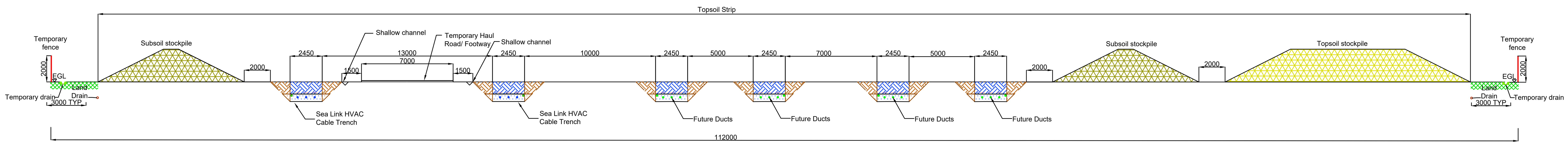
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC CONSTRUCTION AREA FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1



Typical Construction Area - Sea Link
Scale 1:200



Typical Construction Area - Sea Link + One Further Project
Scale 1:200



Typical Construction Area - Sea Link + Two Further Projects
Scale 1:200

SCALE BAR (METRES)

1:200 0 10m 20m

Notes

For statutory consultation purposes only.

These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

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Legend

- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC CONSTRUCTION AREA FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1

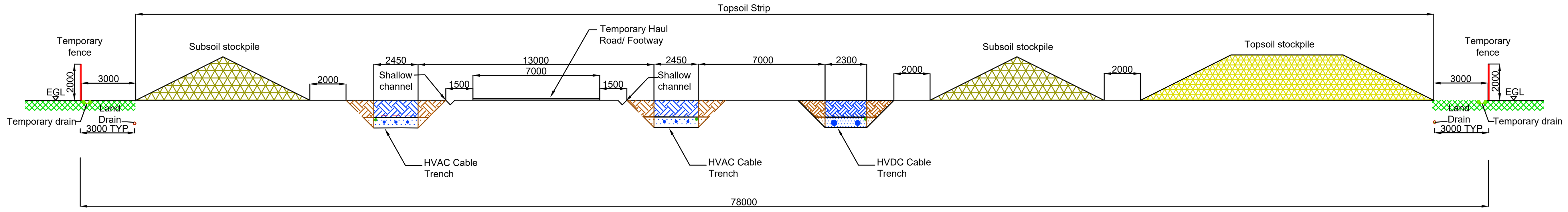
nationalgrid

Application Number
EN020026

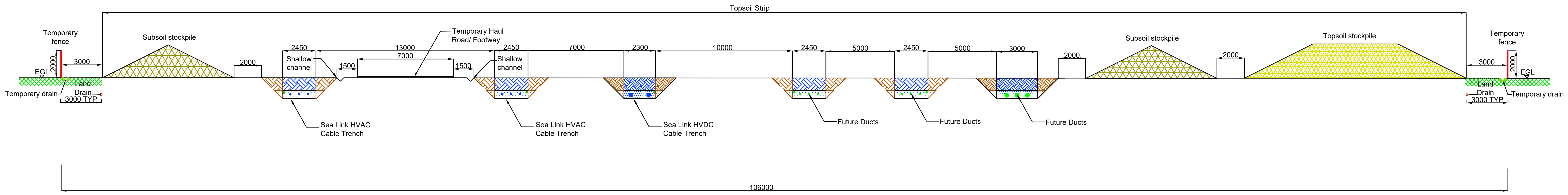
National Grid Drawing Reference
S42_S/TDD/SS/0013

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

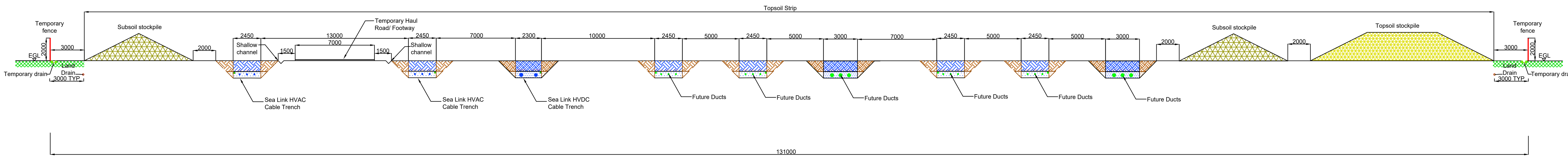
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC AND HVDC COMBINED CONSTRUCTION AREA
FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1



Typical Construction Area - Sea Link
Scale 1:200



Typical Construction Area - Sea Link + One Further Project
Scale 1:200



Typical Construction Area - Sea Link + Two Further Projects
Scale 1:200

SCALE BAR (METRES)
1:200 0 10m 20m

Notes

For statutory consultation purposes only.

These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

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Legend

- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC AND HVDC COMBINED CONSTRUCTION AREA
FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS
SHEET 1 OF 1

nationalgrid

Application Number
EN020026

National Grid Drawing Reference
S42_S/TDD/SS/0014

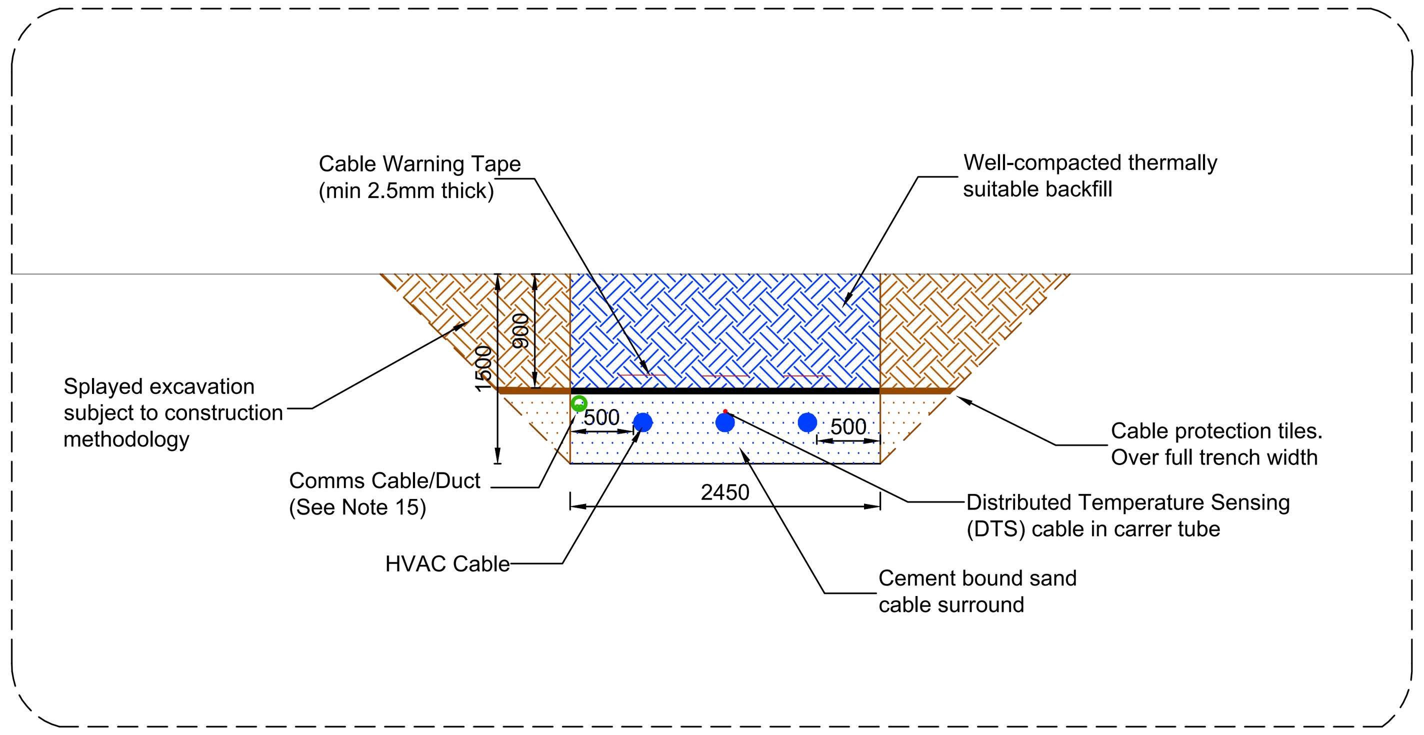
Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

01-04. HVDC & HVAC Arrangement & Cross Sections

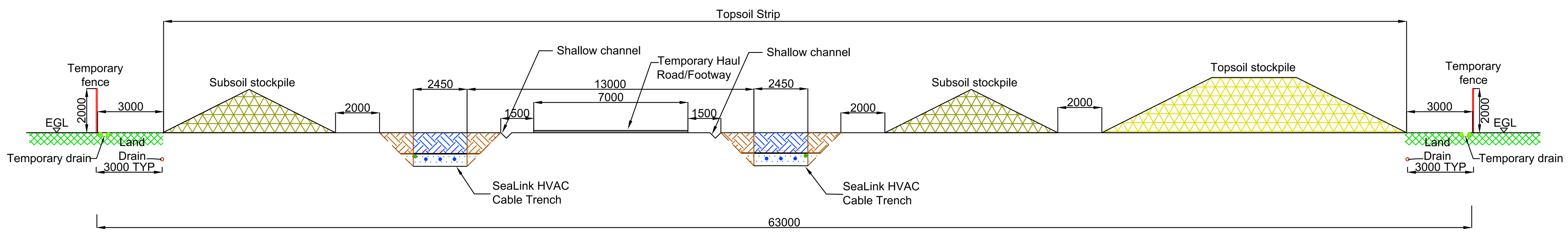
Drawing Category Name	Plan Title	Scheme	Drawing Numbers
HVDC & HVAC Arrangement & Cross Sections	Typical HVAC direct buried cross section and construction area	Suffolk Onshore Scheme	S42_S/TDD/SS/0010
	Typical 400kv HVAC joint bay arrangement	Suffolk Onshore Scheme	S42_S/TDD/SS/0011
	Typical HVAC direct buried cross section and construction area	Onshore Schemes	S42_T/TDD/SS/3001
	Typical HVAC joint bay arrangements	Onshore Schemes	S42_T/TDD/SS/3003
	Typical HVAC and HVDC combined construction area	Suffolk Onshore Scheme	S42_S/TDD/SS/0012

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

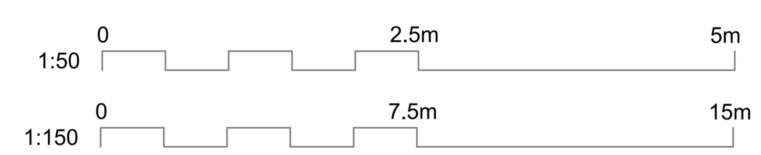
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC DIRECT BURIED CROSS SECTION AND CONSTRUCTION AREA
SHEET 1 OF 1



Direct Buried Cable Cross Section
Scale 1:50



Typical Construction Area - Two Trenches
Scale 1:150



Notes

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These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL HVAC DIRECT BURIED CROSS SECTION AND CONSTRUCTION AREA
SHEET 1 OF 1

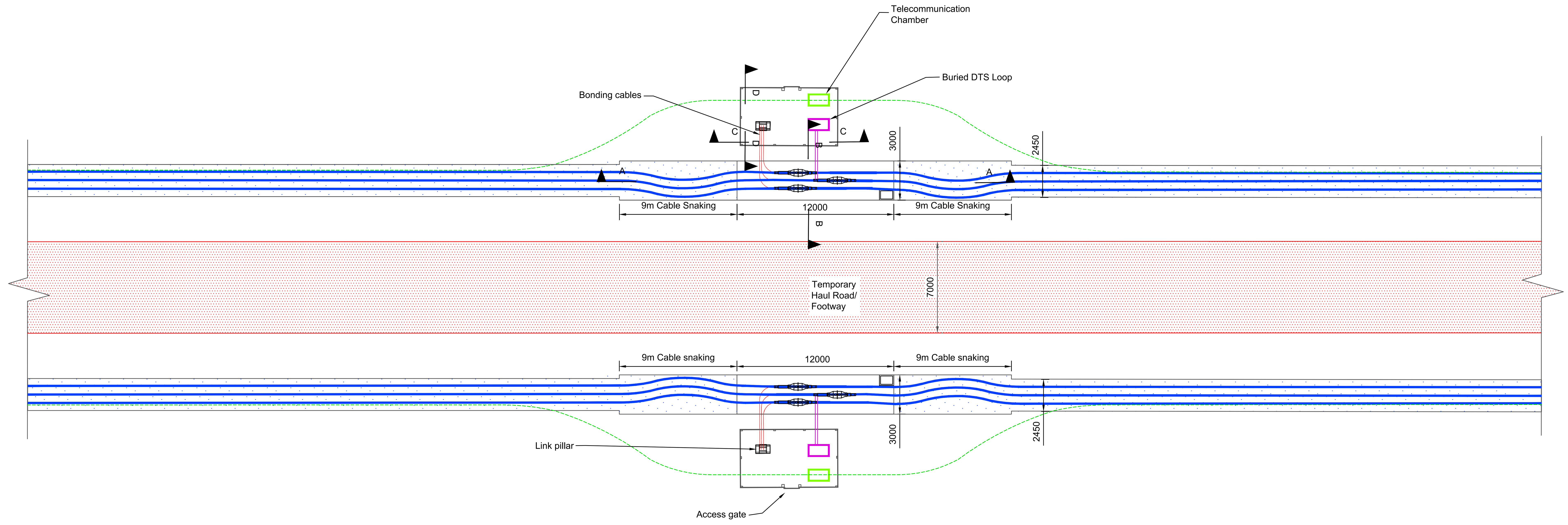
nationalgrid

Application Number
EN020026

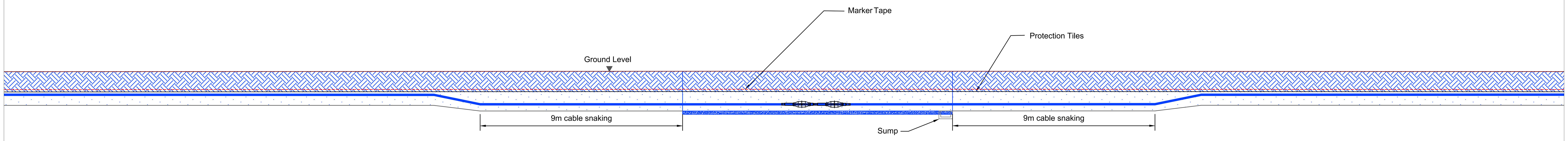
National Grid Drawing Reference
S42_S/TDD/SS/0010

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

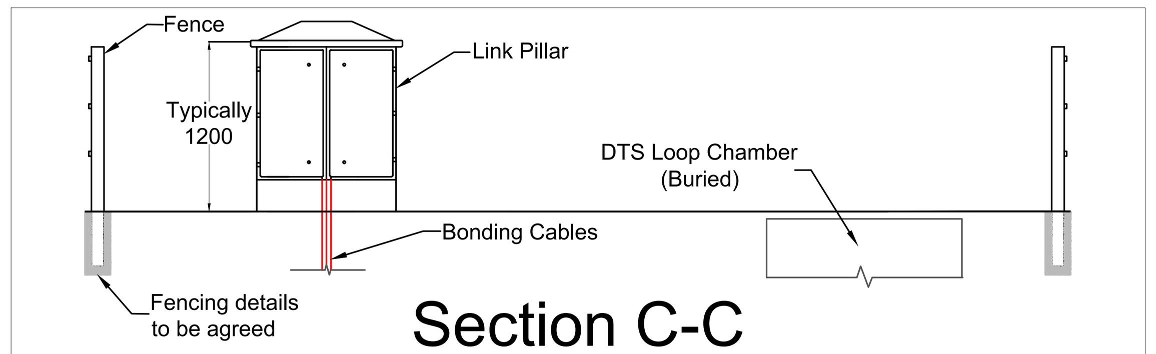
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL 400kV HVAC JOINT BAY ARRANGEMENT
SHEET 1 OF 1



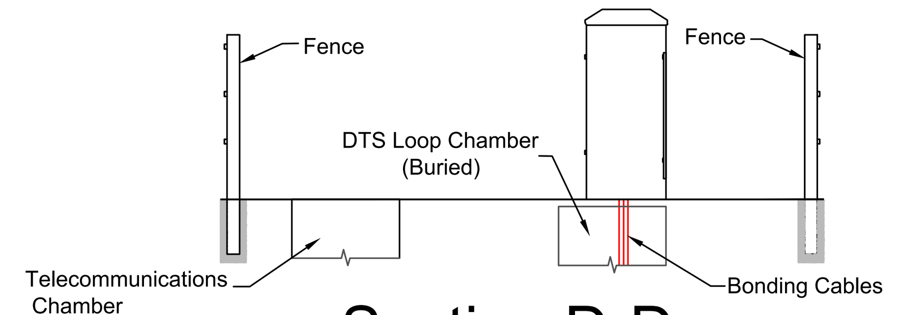
Typical HVAC Cable Joint Bay Layout
Scale 1:200



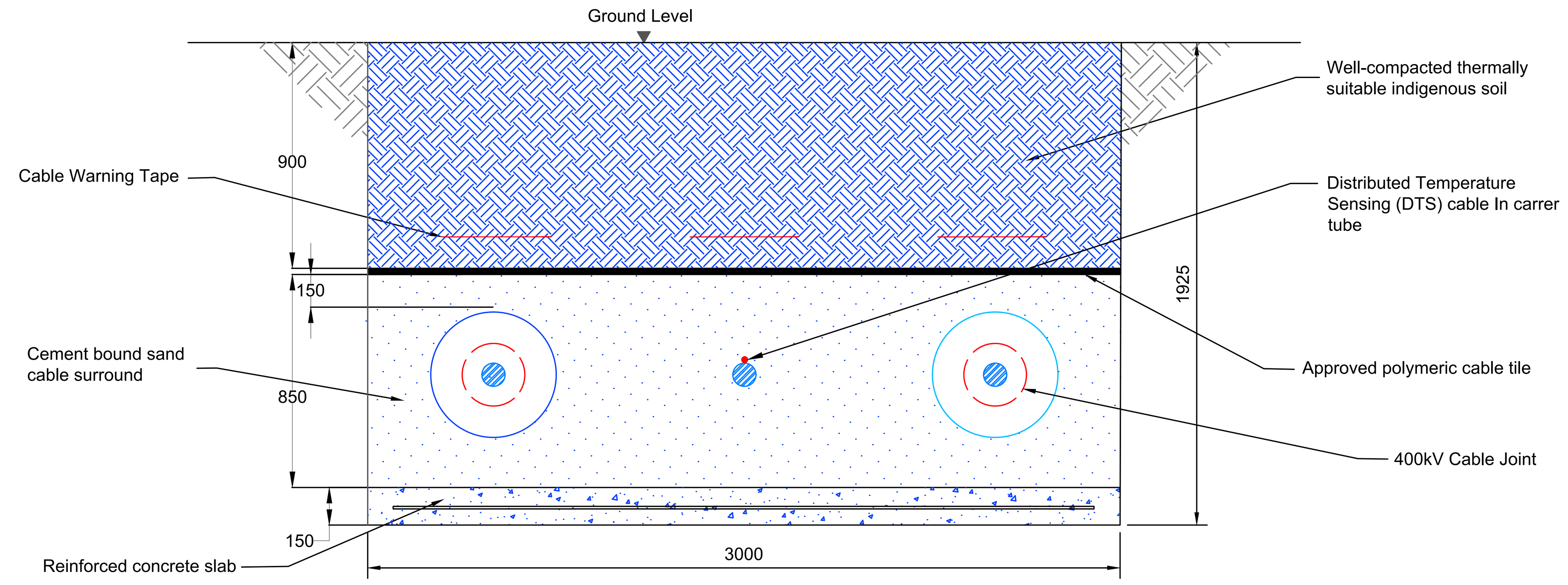
Section A-A
Typical HVAC Cable Joint Bay Long Section
Scale 1:100



Section C-C
Typical Link Pillar Cross Section
Scale 1:50

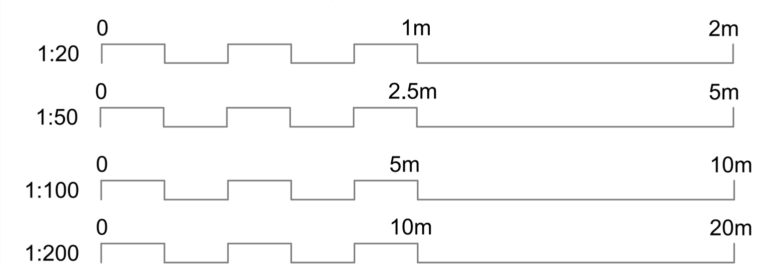


Section D-D
Typical Link Pillar Cross Section
Scale 1:50



Section B-B
Typical HVAC Cable Joint Bay Cross Section
Scale 1:20

SCALE BAR (METRES)



Notes

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These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Cable protection cover
- 400 kV Power Cable
- Bonding Cable
- Cement-bound Sand (CBS)
- Well-compacted thermally suitable indigenous soil
- Concrete
- Temporary Haul Road/ Footway
- Cable Warning Tape
- Telecommunication Chamber
- Distributed Temperature Sensing (DTS) Loop
- Timber Fence
- DTS Cables
- Communication Cable Duct

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL 400kV HVAC JOINT BAY ARRANGEMENT
SHEET 1 OF 1

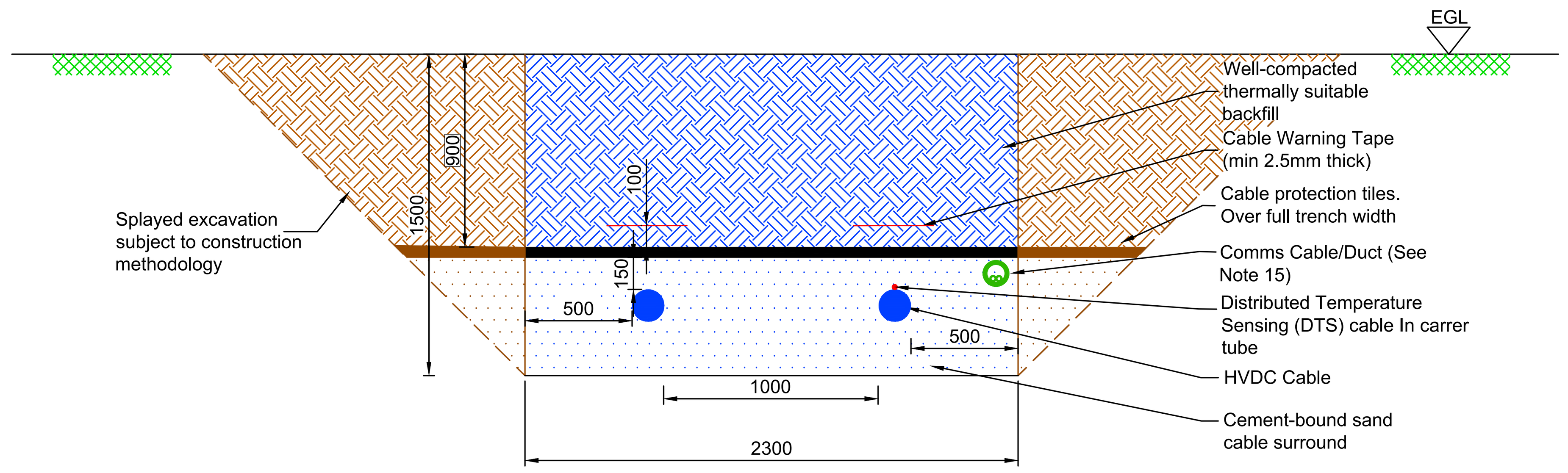
nationalgrid

Application Number
EN020026

National Grid Drawing Reference
S42_S/TDD/SS/0011

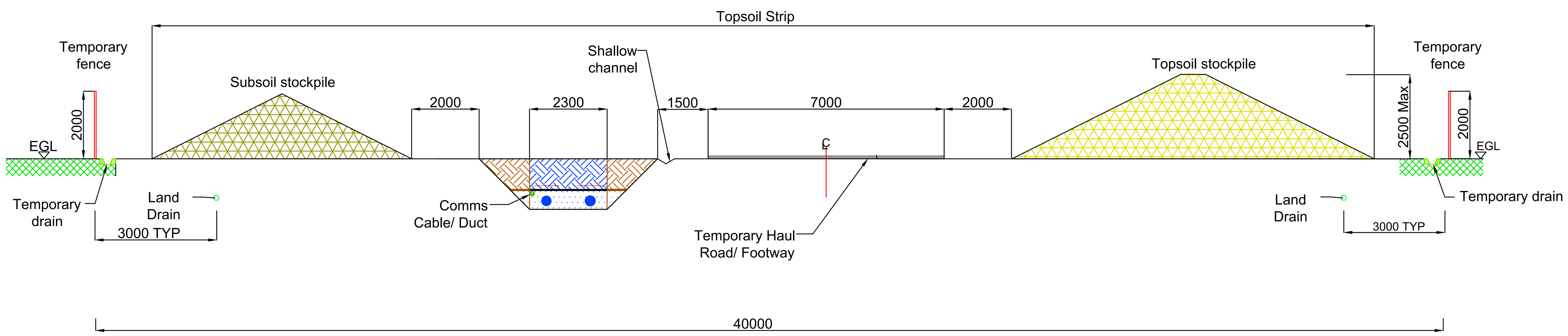
Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVDC DIRECT BURIED CABLE
CROSS SECTION AND CONSTRUCTION AREA
SHEET 1 OF 1



Direct Buried Cable Cross Sections - One Trench

Scale 1:25



Typical Construction Area - One Trench

Scale 1:100

Notes

For statutory consultation purposes only.

These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL HVDC DIRECT BURIED CABLE
CROSS SECTION AND CONSTRUCTION AREA
SHEET 1 OF 1

nationalgrid

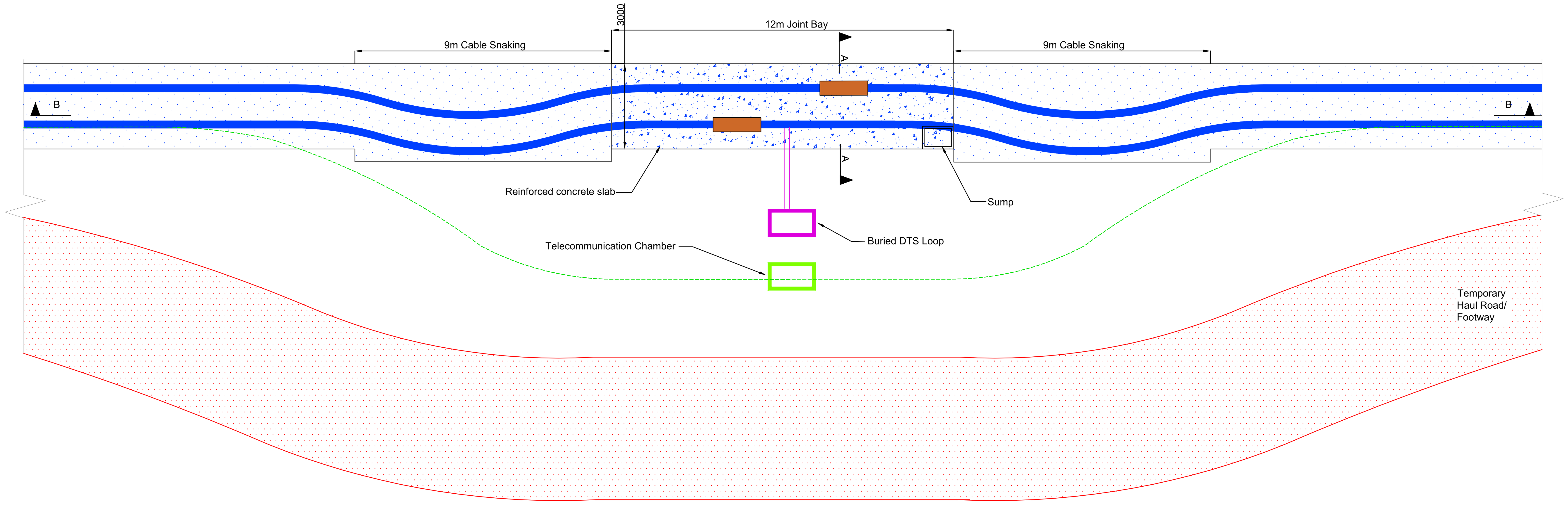
Application Number: EN020026

National Grid Drawing Reference: S42_T/TDD/SS/3001

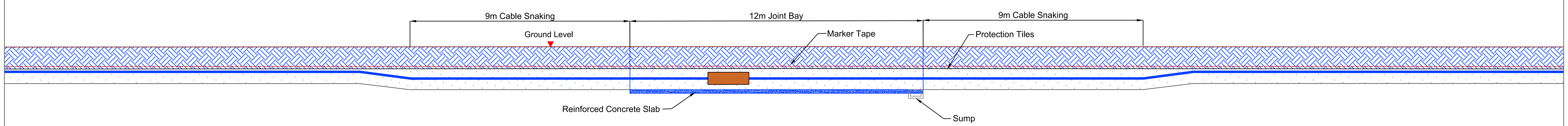
Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

SCALE BAR (METRES)
1:25 — 0, 1.250m, 2.5m
1:100 — 0, 5m, 10m

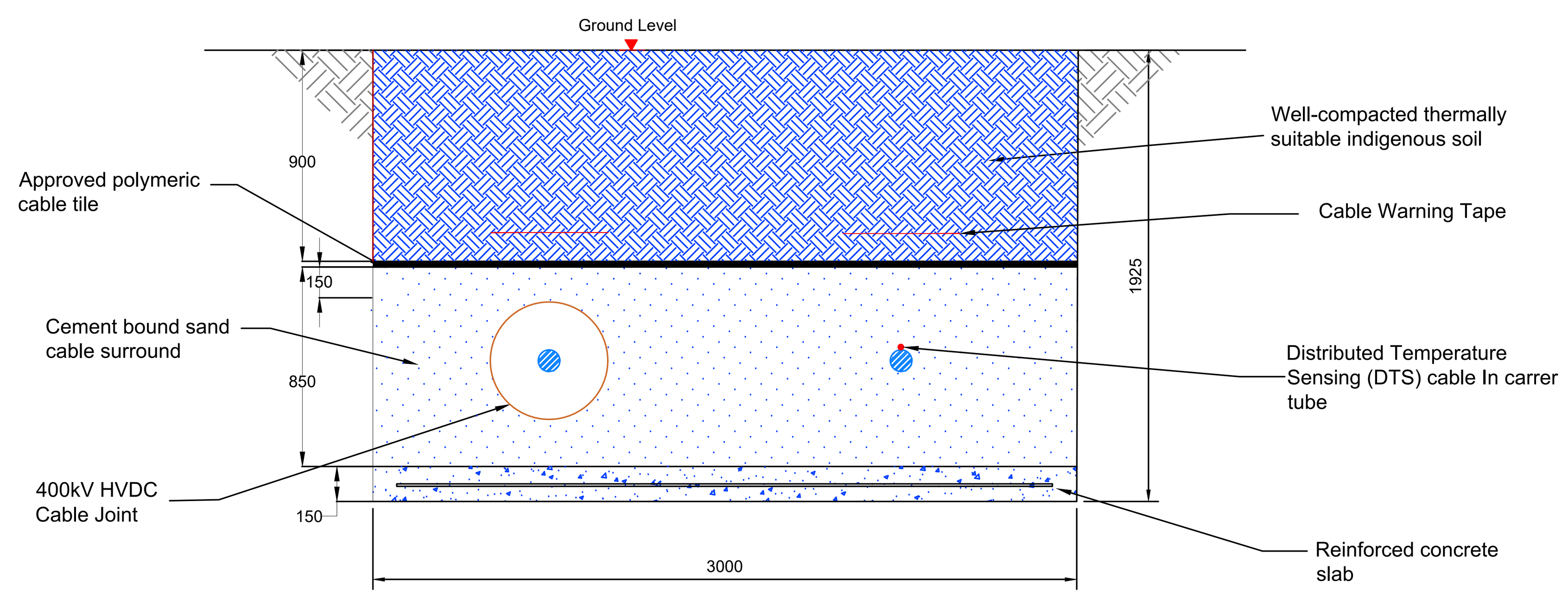
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVDC JOINT BAY ARRANGEMENT
SHEET 1 OF 1



Typical HVDC Cable Joint Bay Layout
Scale 1:100



Section B-B
Typical HVDC Cable Joint Bay Long Section
Scale 1:100



Section A-A
Typical HVDC Cable Joint Bay Cross Section
Scale 1:25

SCALE BAR (METRES)

1:25 — 0, 1.250m, 2.5m

1:100 — 0, 5m, 10m

Notes

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For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Cable protection tiles
- HVDC Cable
- 400kV HVDC Cable Joint
- Cement-bound Sand (CBS)
- Well-compacted thermally suitable backfill
- Concrete
- Temporary Haul Road/ Footway
- Cable Warning Tape
- Telecommunication Chamber
- Distributed Temperature Sensing (DTS) Loop
- DTS Cables
- Communication Cable Duct

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

A	01/09/2023	FINAL	SC	JW	KJ
Issue	Date	Remarks	Drawn	Checked	Approved

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL HVDC JOINT BAY ARRANGEMENT
SHEET 1 OF 1

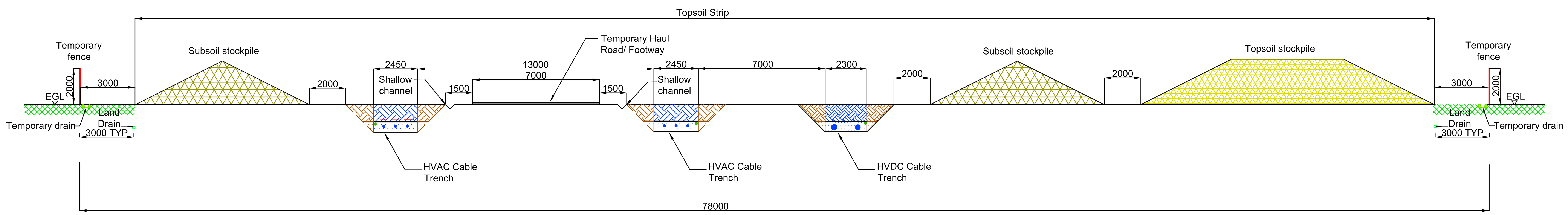
nationalgrid

Application Number: EN020026

National Grid Drawing Reference: S42_T/TDD/SS/3003

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL HVAC AND HVDC COMBINED CONSTRUCTION AREA
SHEET 1 OF 1



Typical Construction Area - HVAC + HVDC
Scale 1:150

SCALE BAR (METRES)
1:150 0 7.5m 15m

Notes
For statutory consultation purposes only.
These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend
- Well-compacted thermally suitable backfill
- Well-compacted thermally suitable backfill (Splayed Excavation)
- Cement-bound sand cable surround
- Cement-bound sand cable surround (Splayed Excavation)
- Cable protection tiles
- Cable warning tape
- Topsoil stockpile
- Subsoil stockpile
- Existing Ground
- Temporary Haul Road/ Footway

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

A	01/09/2023	FINAL	SC	JW	KJ
Issue	Date	Remarks	Drawn	Checked	Approved

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL HVAC AND HVDC COMBINED CONSTRUCTION AREA
SHEET 1 OF 1

nationalgrid

Application Number
EN020026

National Grid Drawing Reference
S42_S/TDD/SS/0012

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

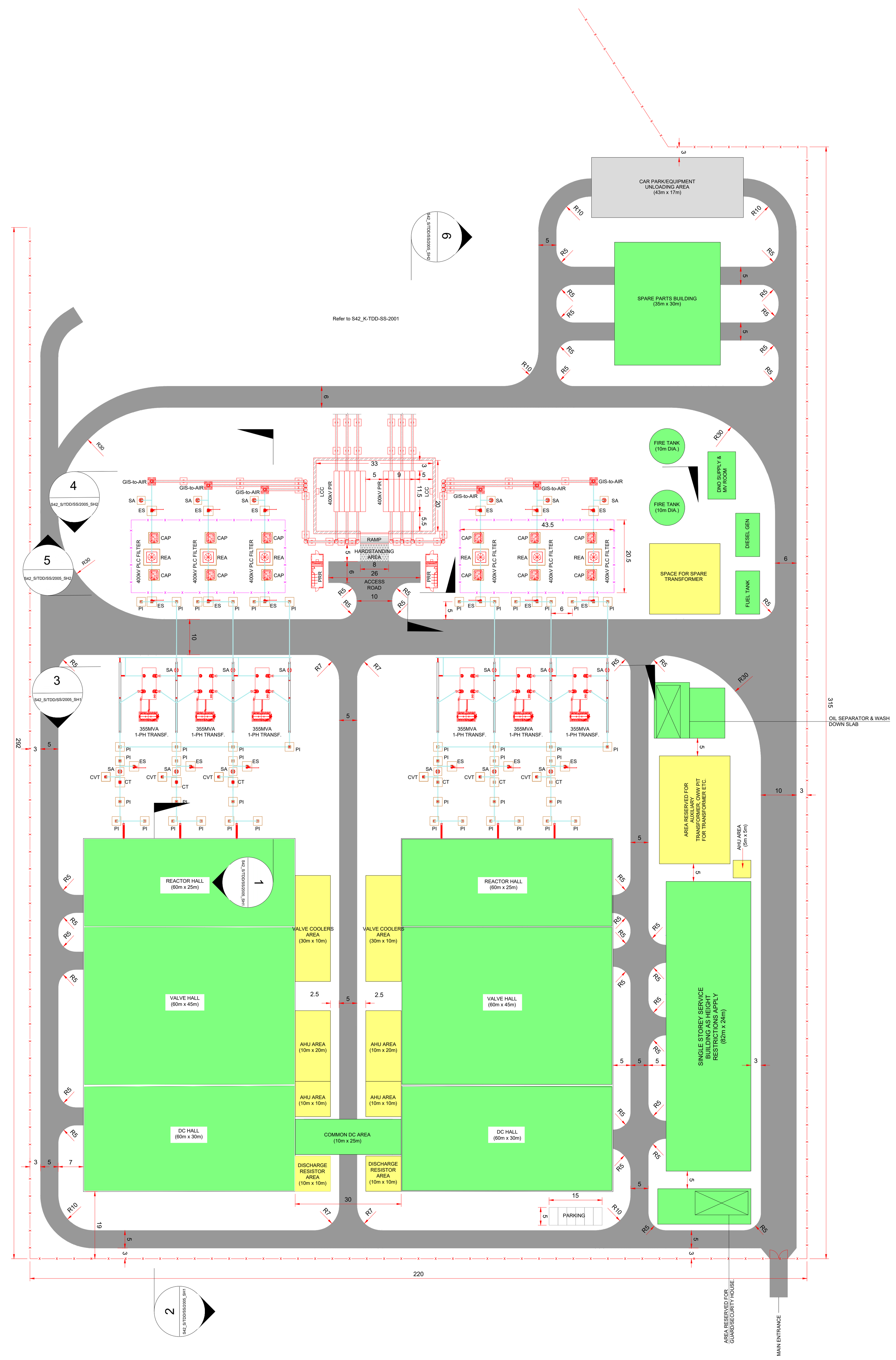
01-05. Minster Converter Station

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Minster Converter Station	Typical Minster converter station - layout plan (GIS)	Kent Onshore Scheme	S42_K/TDD/SS/2002
	Typical minster converter station - elevation drawing	Kent Onshore Scheme	S42_K/TDD/PS/2005_SH1 S42_K/TDD/PS/2005_SH2

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL MINSTER CONVERTER STATION - LAYOUT PLAN (GIS)
SHEET 1 of 1

NOMINAL SYSTEM VOLTAGE	PHASE TO EARTH	PHASE TO PHASE	SAFETY DISTANCE (FROM NATIONAL GRID SAFETY RULES)	DESIGN CLEARANCE FOR SAFETY (VERTICAL) Ds	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL) Dsh	INSULATION HEIGHT Ih
kV	M	M	M	M	M (SEE POINT ii FROM NOTE 10)	M
400	2.8	3.6	3.1	5.5	4.6	2.4



Notes

For statutory consultation purposes only.

1. These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.
2. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
3. Abbreviations
   - PIR - Pre-Insertion Resistor
   - CAP - Capacitor
   - RES - Resistor
   - REA - Reactor
   - PI - Post Insulator
   - CT - Current Transformer
   - CVT - Capacitive Voltage Transformer
   - ES - Earth Switch
   - SA - Surge Arrester
   - PRR - Portable Relay Room
   - LCC - Local Control Cubicle
4. Elevation sections relate to S42_S/TDD/SS/2005_SH1 & S42_S/TDD/SS/2005_SH2.

Legend

- PERIMETER FENCE
- INTERNAL FENCE
- BUILDINGS
- EXTERNAL EQUIPMENT AREAS
- CAR PARK

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL MINSTER CONVERTER STATION - LAYOUT PLAN (GIS)
SHEET 1 of 1

nationalgrid

Application Number
EN020026

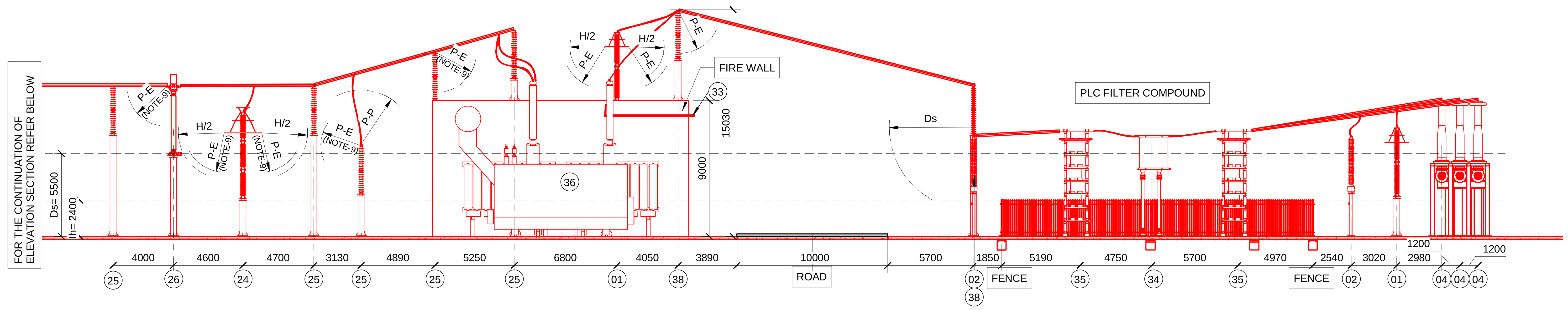
National Grid Drawing Reference
S42_K/TDD/SS/2002

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

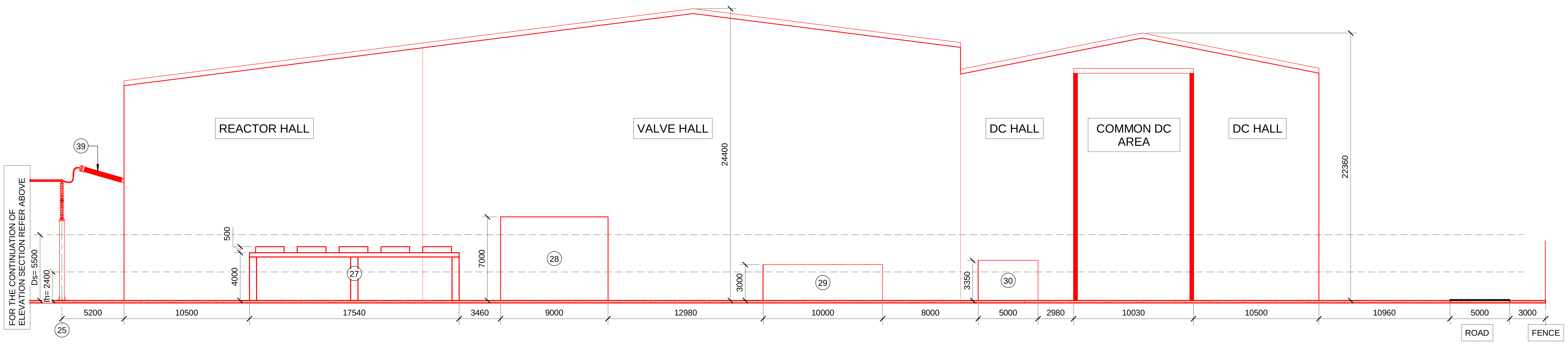
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL MINSTER CONVERTER STATION - ELEVATION DRAWING
SHEET 1 OF 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

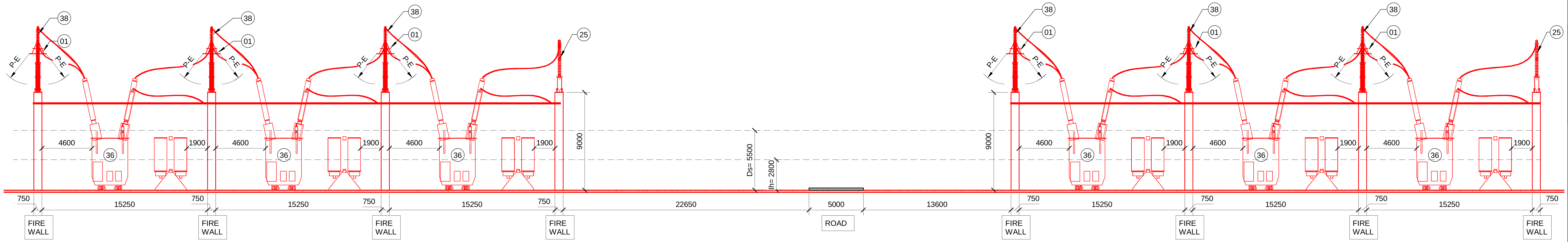
REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



ELEVATION 1
1 : 200



ELEVATION 2
1 : 200



ELEVATION 3
1 : 200

Notes

FOR STATUTORY CONSULTATION PUPOSES ONLY.

1. THESE PLANS SHOW THE DRAFT ORDER LIMITS AND DRAFT CABLE ALIGNMENT AND POTENTIAL PYLON LOCATIONS. DUE TO THE NEED FOR FUTURE FLEXIBILITY, NATIONAL GRID WILL BE APPLYING FOR ORDER LIMITS AND LIMITS OF DEVIATION WITHIN ITS DEVELOPMENT CONSENT ORDER, WITHIN WHICH ANY FINAL ALIGNMENT (INCLUDING PYLON LOCATIONS) WOULD LIE. THEREFORE THE DRAFT CABLE ALIGNMENT AND PYLON LOCATIONS SHOULD BE TREATED AS INDICATIVE ONLY. FURTHER INFORMATION IS PROVIDED IN OUR 'GUIDE TO INTERACTING WITH OUR CONSULTATION PLANS' DOCUMENT.
2. FOR FURTHER INFORMATION ON CONSTRUCTION PLEASE REFER TO THE CONSTRUCTION SECTION OF THE PRELIMINARY ENVIRONMENTAL IMPACT REPORT, VOLUME 1, PART 1, CHAPTER 4.
3. ABBRIVIATION
   - PLC - POWER LINE CARRIER
   - AIS - AIR INSULATED SWITCHGEAR
   - CVT - CAPACITIVE VOLTAGE TRANSFORMER
   - GIS - GAS INSULATED SWITCHGEAR
   - PIR - PRE INSERTION RESISTOR
   - LCC - LOCAL CONTROL CUBICLE
   - PH - PHASE
   - GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
06	400kV GIS HALL
20	LCC
21	ROLLING SHUTTER
22	550KV AIS CVT
23	550KV AIS EARTH SWITCH
24	550KV AIS SURGE ARRESTOR
25	550KV POST INSULATOR
26	550KV CURRENT TRANSFORMER
27	EXTERNAL FIN FAN COOLER
28	BUILDING FOR PUMP SKID COOLING SYSTEM
29	AHU FOR REACTOR & VALVE HALL BUILDING
30	AHU FOR DC HALL BUILDING
31	PORTABLE RELAY ROOM
32	400 kV PIR
33	11kV POST INSULATOR
34	400 kV PLC FILTER - REACTOR
35	400 kV PLC FILTER - CAPACITOR
36	400 kV 1PH TRANSFORMER
38	400 kV AIS POST INSULATOR
39	AIR BUSHING WALL PENETRATION

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL MINSTER CONVERTER STATION - ELEVATION DRAWING

SHEET 1 OF 2

Application Number
EN020026

National Grid Drawing Reference
S42_K/TDD/PS/2005

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 1 OF 2	A

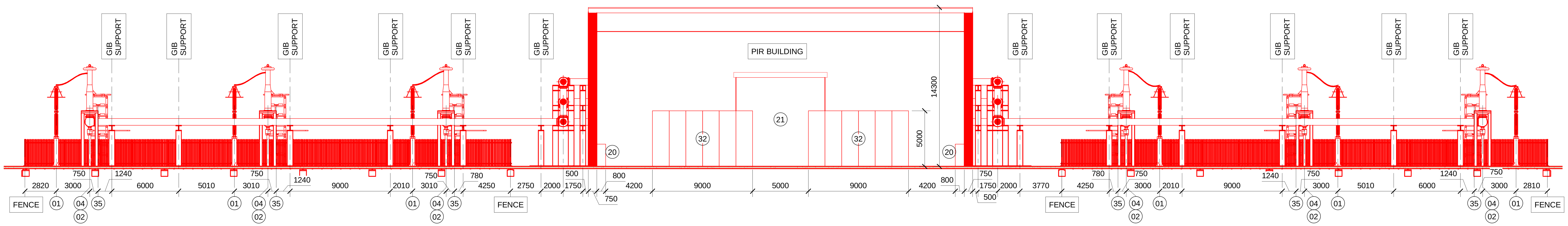
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

TYPICAL MINSTER CONVERTER STATION - ELEVATION DRAWING

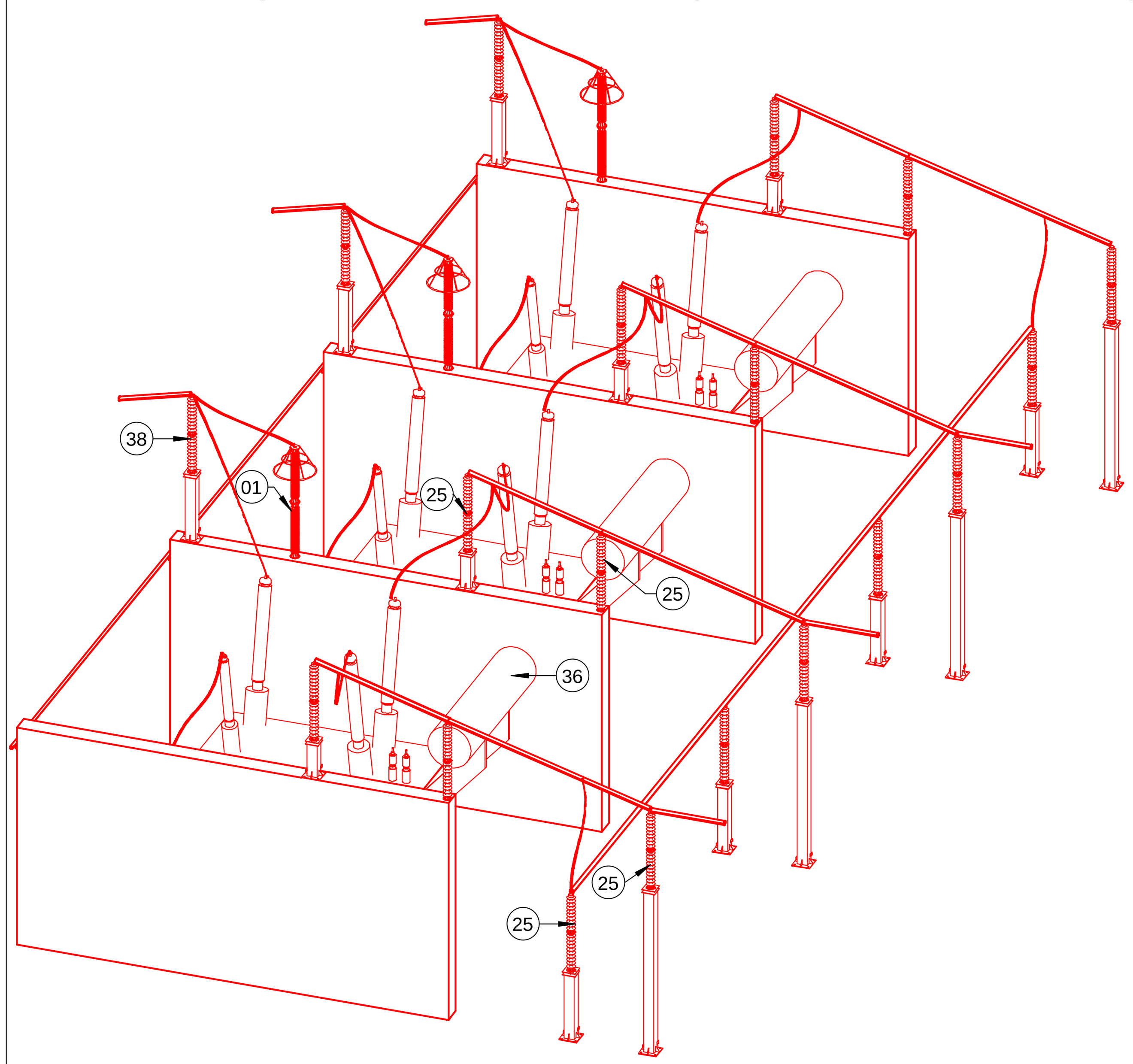
SHEET 2 OF 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

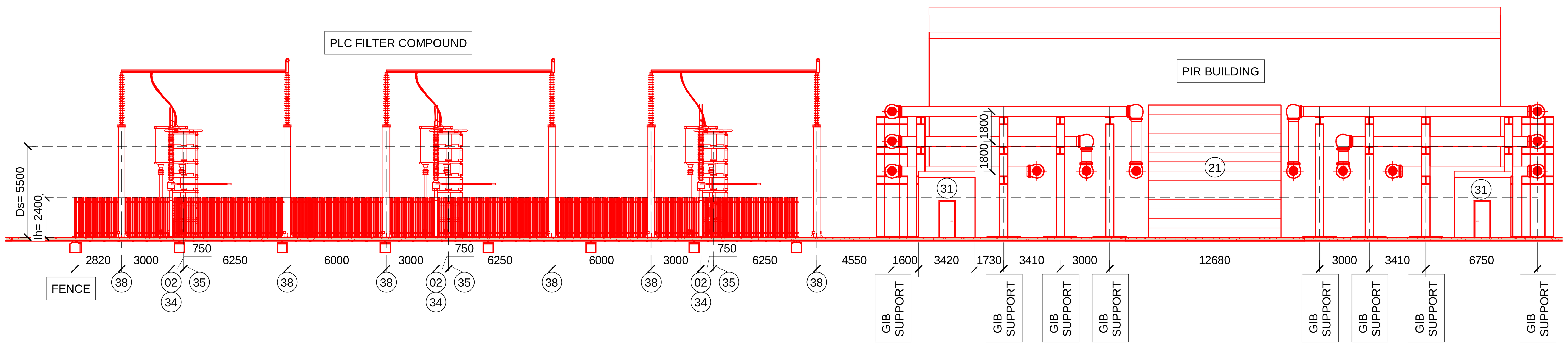
REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



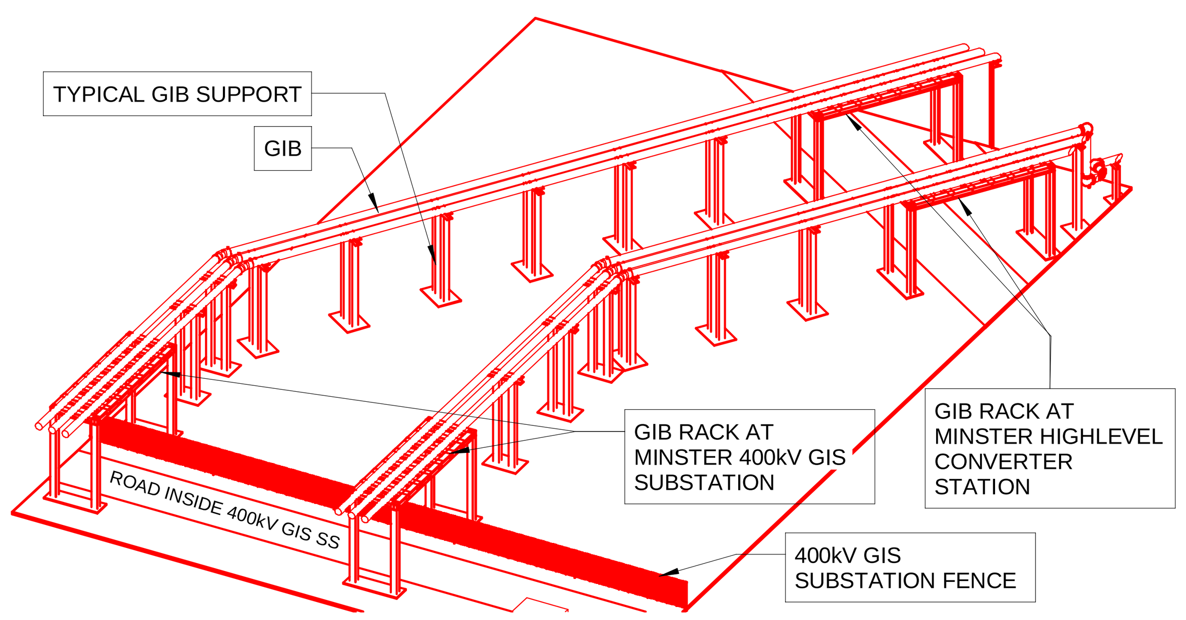
ELEVATION 4
1 : 200



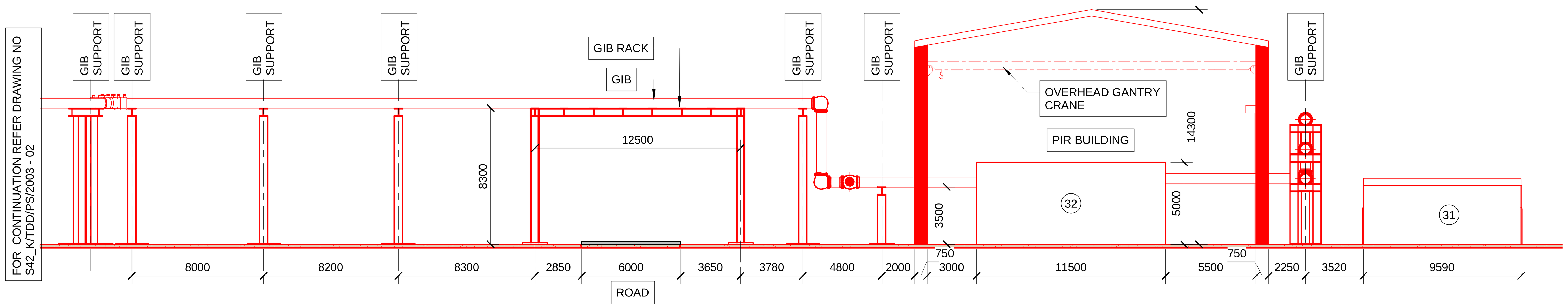
Transformer Area Isometric View



ELEVATION 5
1 : 200



Isometric View for GIB connection between Minster 400 kV Substation and HVDC converter station



ELEVATION 6
1 : 200

Notes

FOR STATUTORY CONSULTATION PUPOSES ONLY.

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2. FOR FURTHER INFORMATION ON CONSTRUCTION PLEASE REFER TO THE CONSTRUCTION SECTION OF THE PRELIMINARY ENVIRONMENTAL IMPACT REPORT, VOLUME 1, PART 1, CHAPTER 4.
3. ABBRIVIATION

PLC - POWER LINE CARRIER
AIS - AIR INSULATED SWITCHGEAR
CVT - CAPACITIVE VOLTAGE TRANSFORMER
GIS - GAS INSULATED SWITCHGEAR
PIR - PRE INSERTION RESISTOR
LCC - LOCAL CONTROL CUBICLE
PH - PHASE
GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
06	400kV GIS HALL
20	LCC
21	ROLLING SHUTTER
22	550KV AIS CVT
23	550KV AIS EARTH SWITCH
24	550KV AIS SURGE ARRESTOR
25	550KV POST INSULATOR
26	550KV CURRENT TRANSFORMER
27	EXTERNAL FIN FAN COOLER
28	BUILDING FOR PUMP SKID COOLING SYSTEM
29	AHU FOR REACTOR & VALVE HALL BUILDING
30	AHU FOR DC HALL BUILDING
31	PORTABLE RELAY ROOM
32	400 kV PIR
33	11kV POST INSULATOR
34	400 kV PLC FILTER - REACTOR
35	400 kV PLC FILTER - CAPACITOR
36	400 kV 1PH TRANSFORMER
38	400 kV AIS POST INSULATOR
39	AIR BUSHING WALL PENETRATION

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL MINSTER CONVERTER STATION - ELEVATION DRAWING

SHEET 2 OF 2

nationalgrid

Application Number: EN020026

National Grid Drawing Reference: S42_K/TDD/PS/2005

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 2 OF 2	A

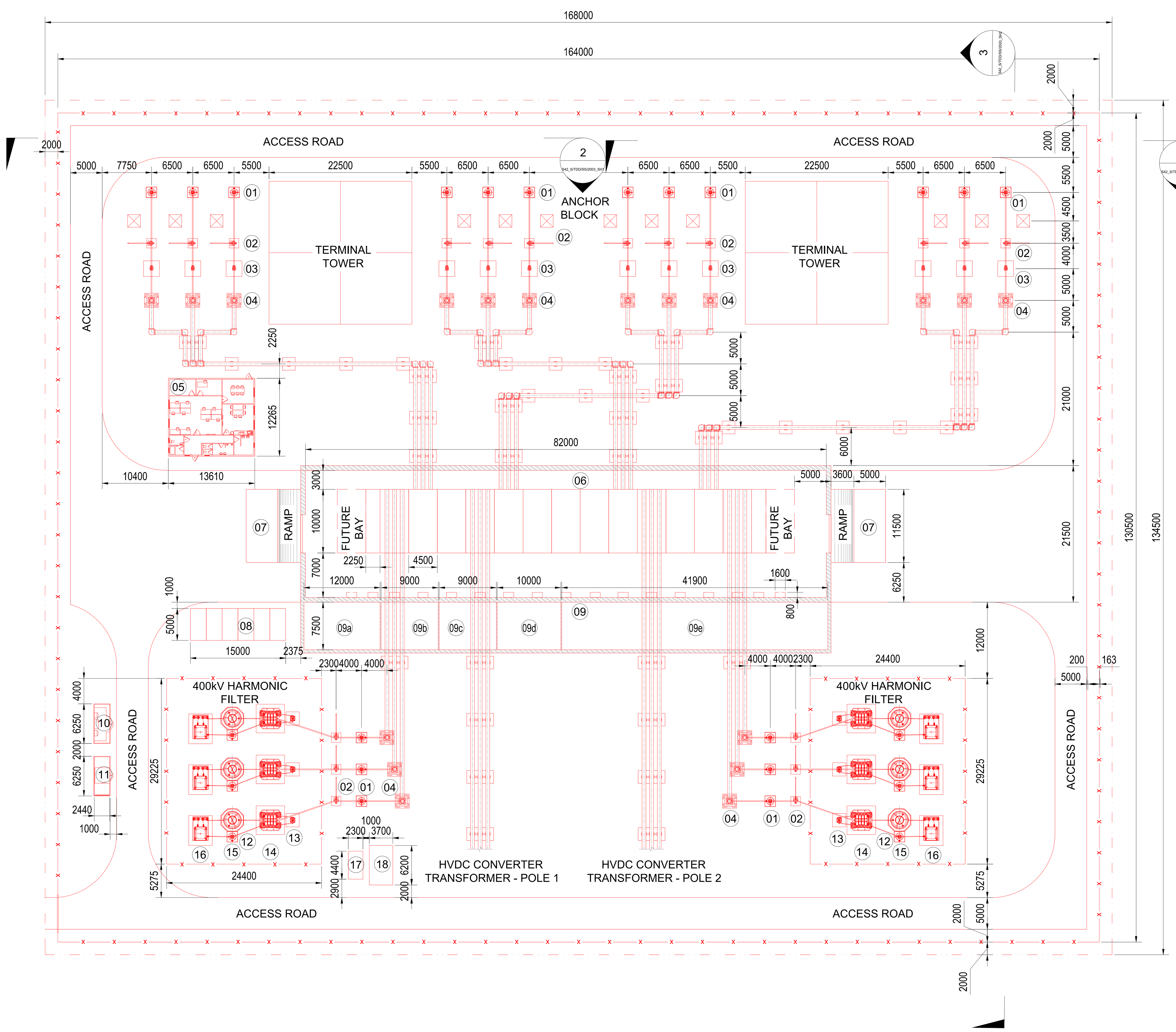
01-06. Minster 400kV Substation

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Minster 400kV Substation	Typical Minster 400kV GIS substation - overall layout	Kent Onshore Scheme	S42_K/TDD/SS/2001
	Typical 400kV GIS substation - elevation drawing	Kent Onshore Scheme	S42_K/TDD/PS/2003_SH1 S42_K/TDD/PS/2003_SH2

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL MINSTER 400KV GIS SUBSTATION - OVERALL LAYOUT
SHEET 1 of 1

NOMINAL SYSTEM VOLTAGE	PHASE TO EARTH	PHASE TO PHASE	SAFETY DISTANCE (FROM NATIONAL GRID SAFETY RULES)	DESIGN CLEARANCE FOR SAFETY (VERTICAL) Ds	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL) Dsh	INSULATION HEIGHT Ih
kV	M	M	M	M	M (SEE POINT ii FROM NOTE 6)	M
400	2.8	3.6	3.1	5.5	4.6	2.4



1:500 0 25m 50m

Notes

For statutory consultation purposes only.

1. These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.
2. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
3. Abbreviations
   - AIS - Air Insulated Switchgear
   - CVT - Capacitive Voltage Transformer
   - GIS - Gas Insulated Switchgear
   - LVAC - Low Voltage Alternating Current
   - HVDC- High Voltage Direct Current
4. Elevation sections relate to S42_S/TDD/SS/2003_SH1 & S42_S/TDD/SS/2003_SH2.

Legend

- LIMIT OF LAND
- FENCE
- NEW EQUIPMENT

ID	DESCRIPTION
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
05	AMENITIES BUILDING
06	400kV GIS HALL
07	HARDSTANDING AREA
08	PARKING
09	400kV ANNEX BUILDING
09a	BATTERY ROOM
09b	LVAC SUPPLIES DISTRIBUTION ROOM
09c	TELECOMS ROOM
09d	SUBSTATION CONTROL SYSTEM/PERMIT ROOM
09e	PROTECTION ROOM
10	WORKSHOP
11	STORAGE
12	SURGE ARRESTOR
13	CURRENT TRANSFORMER
14	CAPACITOR
15	REACTOR
16	RESISTOR
17	DIESEL TANK
18	EMERGENCY DIESEL GENERATOR

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL MINSTER 400KV GIS SUBSTATION - OVERALL LAYOUT
SHEET 1 of 1

nationalgrid

Application Number: EN020026

National Grid Drawing Reference: S42_K/TDD/SS/2001

Scale	Sheet Size	Sheet	Issue
1:500	A1	SHEET 1 OF 1	A

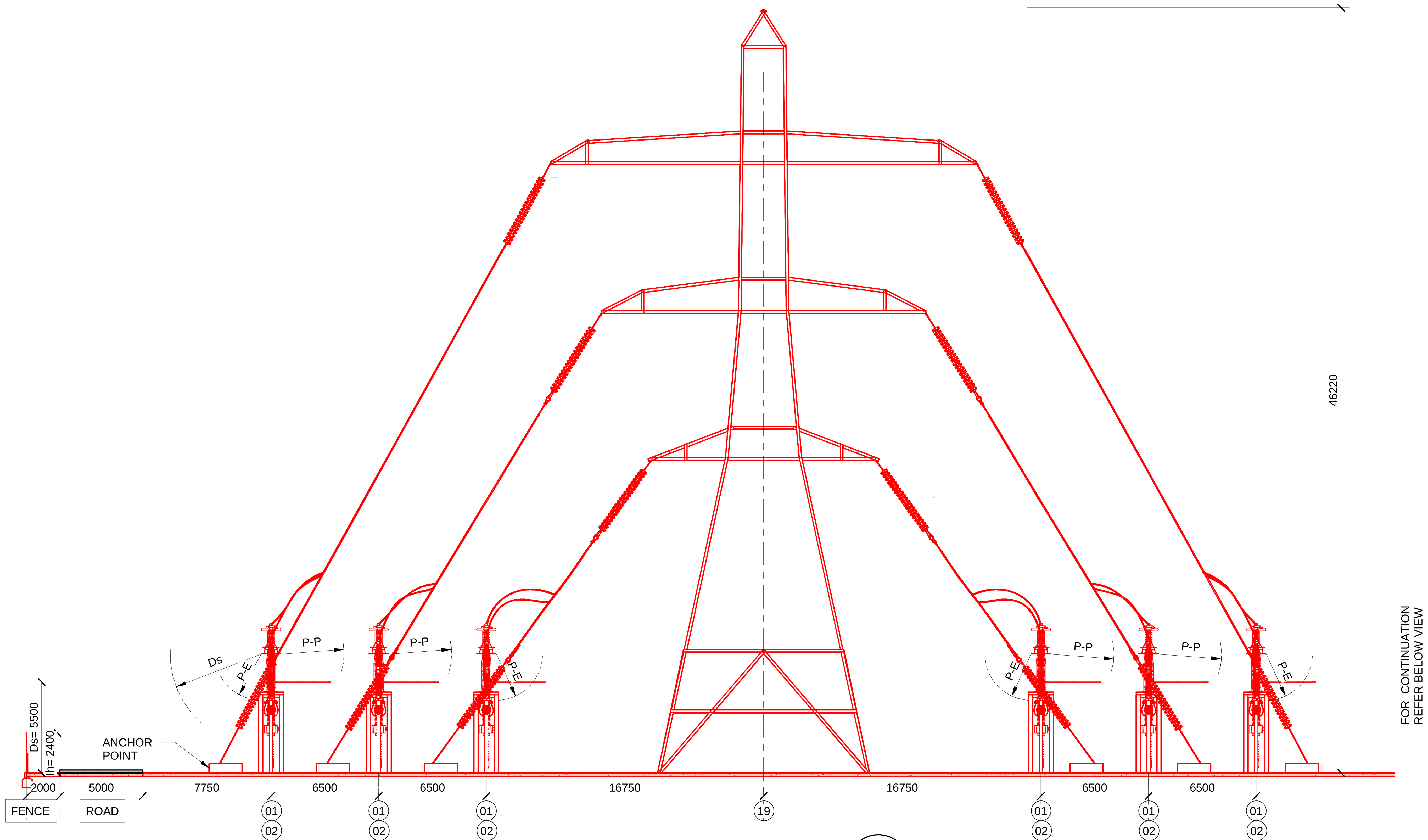
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL 400kV GIS SUBSTATION - ELEVATION DRAWING

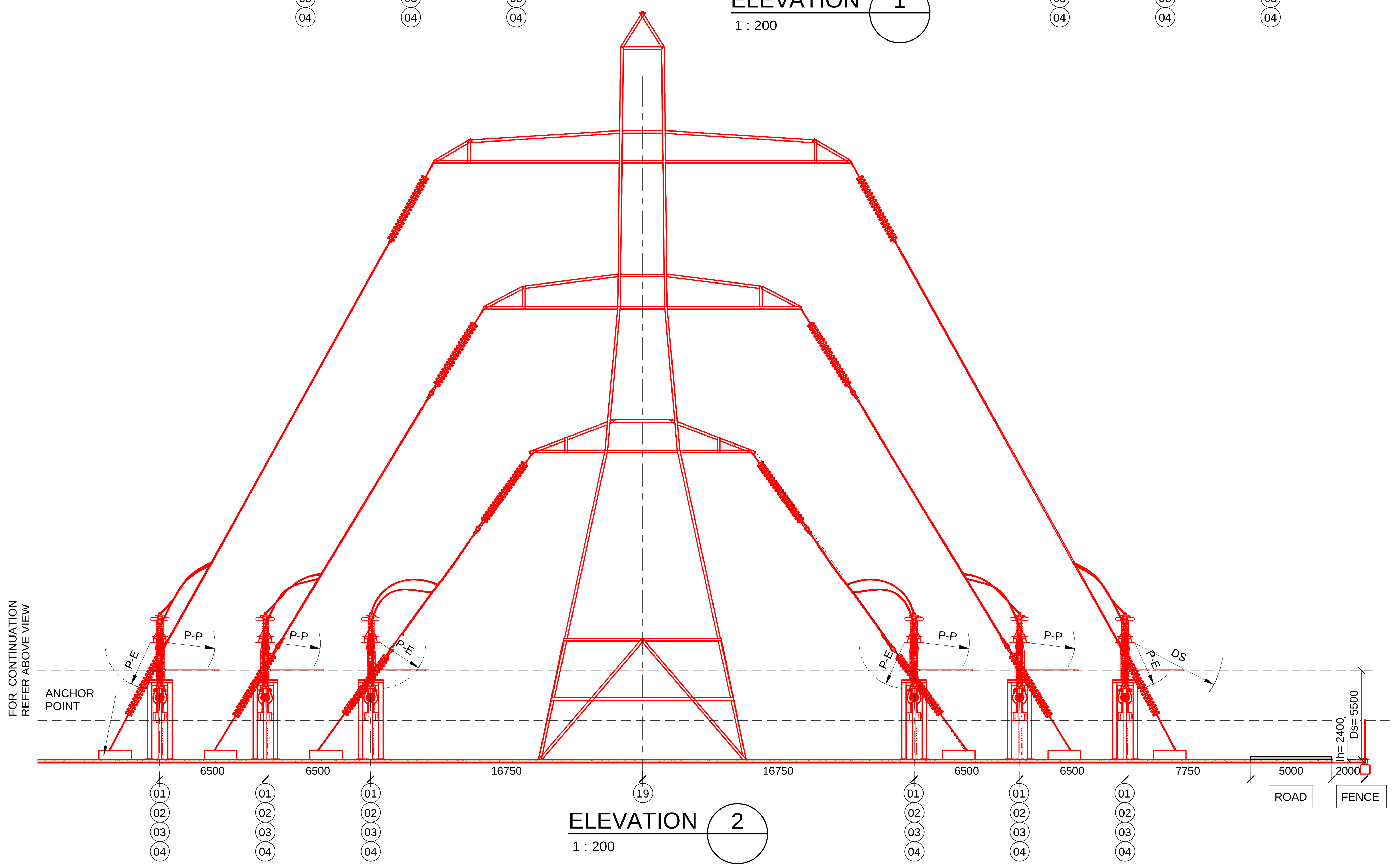
SHEET 1 of 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES		
REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



ELEVATION 1

1 : 200



ELEVATION 2

1 : 200

Notes

FOR STATUTORY CONSULTATION PUPOSES ONLY.

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3. ABBRIVIATION

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AIS - AIR INSULATED SWITCHGEAR
CVT - CAPACITIVE VOLTAGE TRANSFORMER
GIS - GAS INSULATED SWITCHGEAR
PIR - PRE INSERTION RESISTOR
LCC - LOCAL CONTROL CUBICLE
PH - PHASE
GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
06	400kV GIS HALL
13	400 kV HARMONIC FILTER - CURRENT TRANSFORMER
14	400 kV HARMONIC FILTER - CAPACITOR
15	400 kV HARMONIC FILTER - REACTOR
16	400 kV HARMONIC FILTER - RESISTOR
19	400kV TERMINAL TOWER
20	LCC

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL 400kV GIS SUBSTATION - ELEVATION DRAWING

SHEET 1 of 2

nationalgrid

Application Number: EN020026

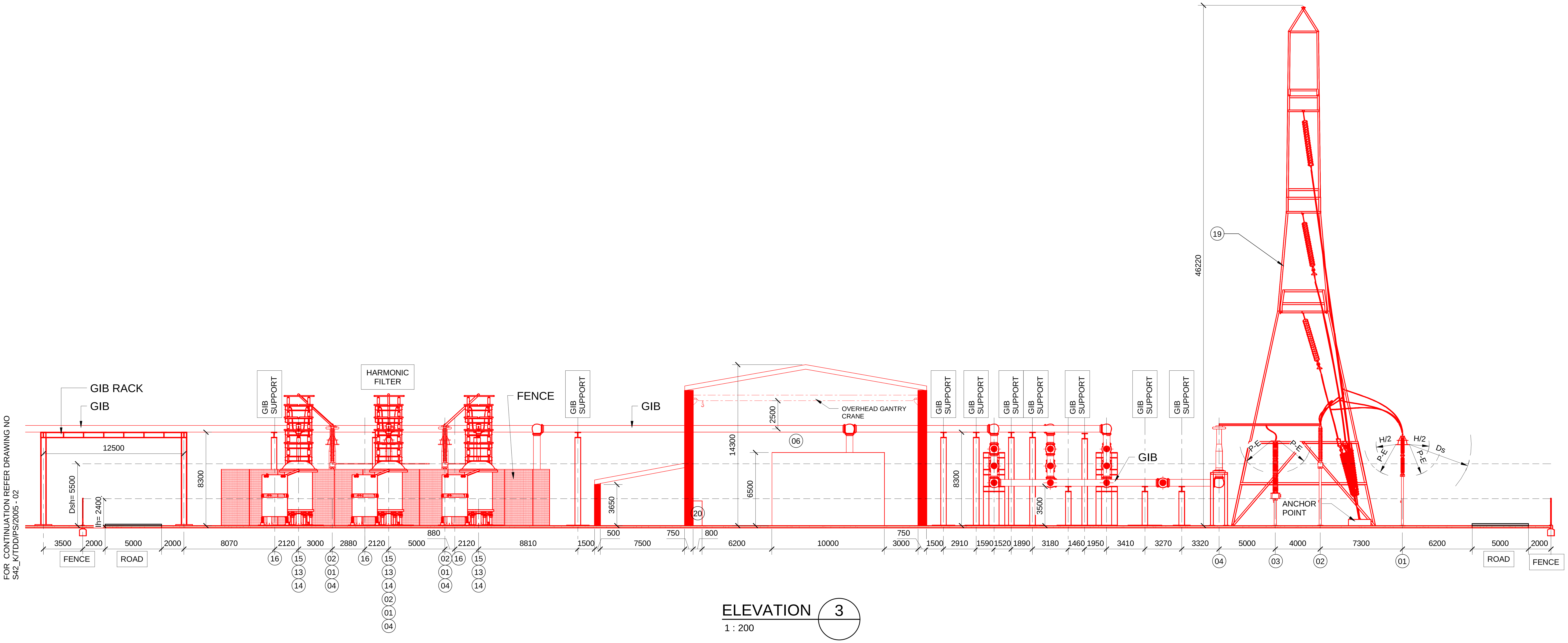
National Grid Drawing Reference: S42_K/TDD/PS/2003

Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 1 of 2	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL 400kV GIS SUBSTATION - ELEVATION DRAWING
SHEET 2 OF 2

SUBSTATION MINIMUM ELECTRICAL CLEARANCES

REF	CLEARANCE (mm)	NOMINAL SYSTEM VOLTAGE 400kV
P-E	PHASE TO EARTH	2800
P-P	PHASE TO PHASE	3600
SD	SAFETY DISTANCE NATIONAL GRID SAFETY RULES	3100
Ds	DESIGN CLEARANCE FOR SAFETY (VERTICAL)	5500
Dsh	DESIGN CLEARANCE FOR SAFETY (HORIZONTAL)	4600
Ih	INSULATION HEIGHT	2400



ELEVATION 3
1 : 200

Notes

FOR STATUTORY CONSULTATION PUPOSES ONLY.

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3. ABBRIVIATION
   - PLC - POWER LINE CARRIER
   - AIS - AIR INSULATED SWITCHGEAR
   - CVT - CAPACITIVE VOLTAGE TRANSFORMER
   - GIS - GAS INSULATED SWITCHGEAR
   - PIR - PRE INSERTION RESISTOR
   - LCC - LOCAL CONTROL CUBICLE
   - PH - PHASE
   - GIB - GAS INSULATED BUSDUCT

Legend

New Equipment

Equipment Schedule

Item	Description
01	400kV AIS SURGE ARRESTOR
02	400kV AIS EARTH SWITCH
03	400kV AIS CVT
04	400kV GIS / AIR BUSHING
06	400kV GIS HALL
13	400 kV HARMONIC FILTER - CURRENT TRANSFORMER
14	400 kV HARMONIC FILTER - CAPACITOR
15	400 kV HARMONIC FILTER - REACTOR
16	400 kV HARMONIC FILTER - RESISTOR
19	400kV TERMINAL TOWER
20	LCC

Issue	Date	Remarks	Drawn	Checked	Approved
A	08/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

TYPICAL 400kV GIS SUBSTATION - ELEVATION DRAWING

SHEET 2 OF 2

nationalgrid

Application Number: EN020026

National Grid Drawing Reference: S42_K/TDD/PS/2003

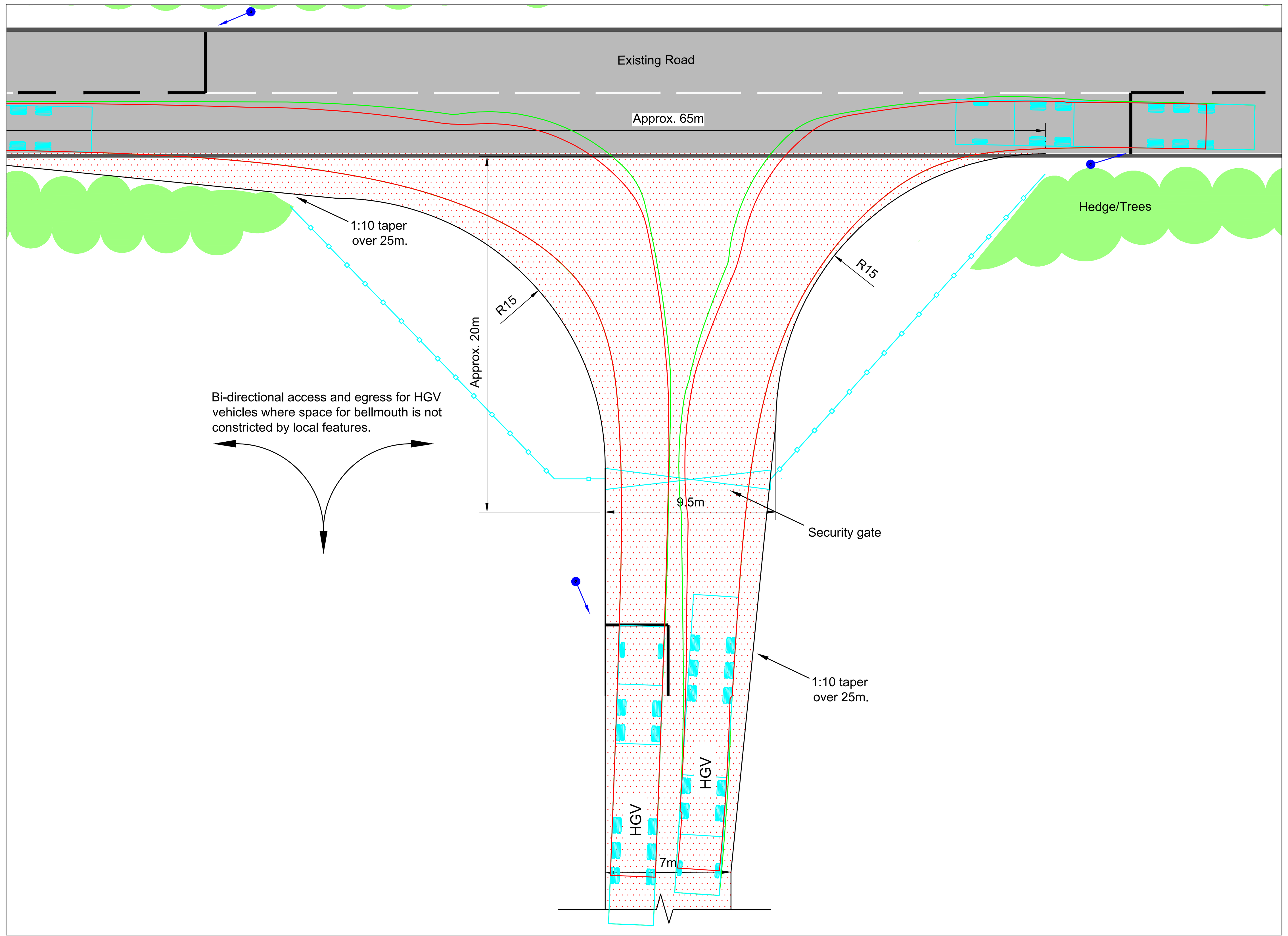
Scale	Sheet Size	Sheet	Issue
1 : 200	A1	SHEET 2 OF 2	A

01-07. Bellmouths, Compounds & Pylon Types

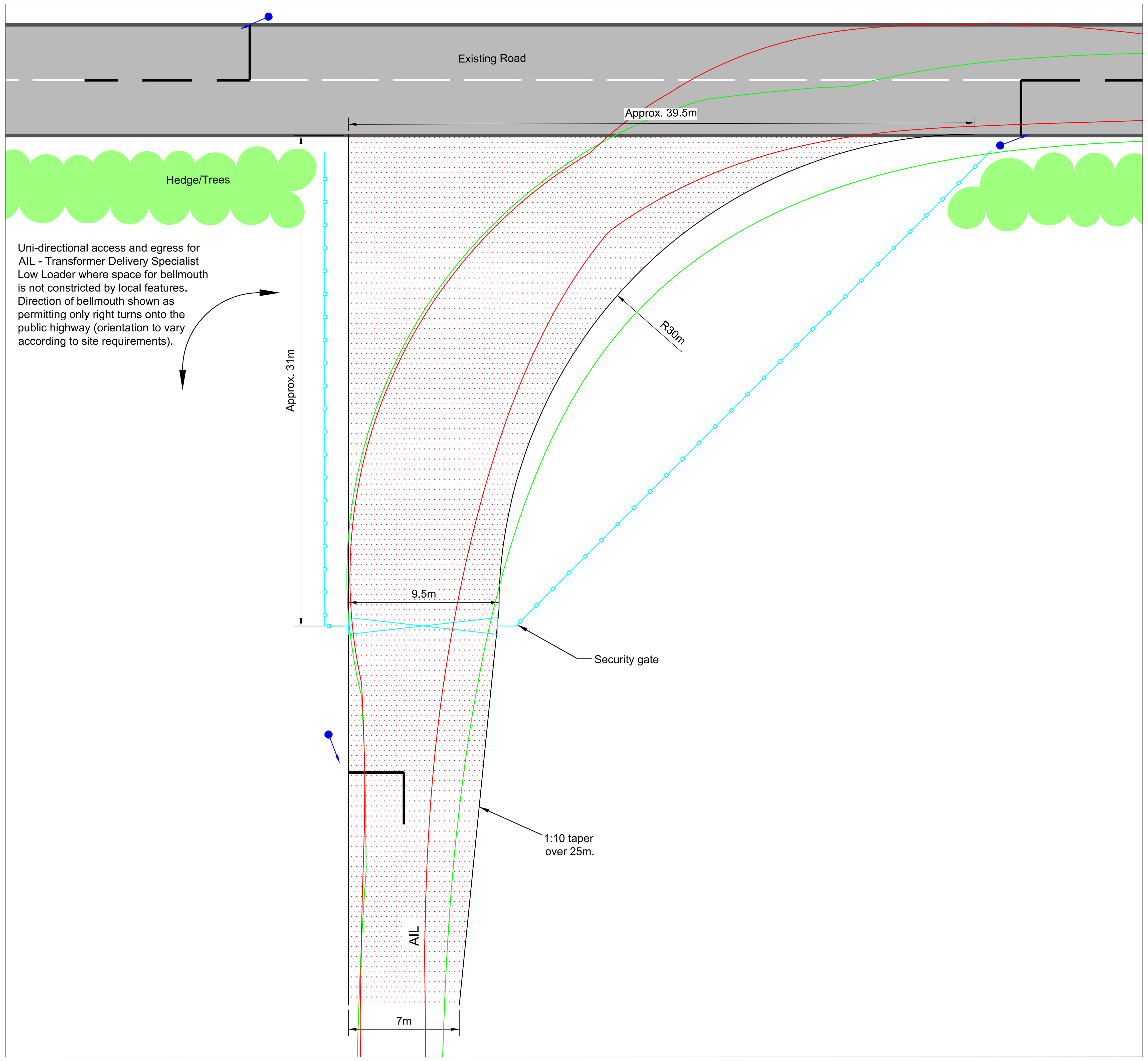
Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Compounds, Bellmouths & Pylon Types	Typical bellmouth arrangement details	Onshore Schemes	S42_T/TDD/SS/3002
	Typical OHL and construction works construction compound	Onshore Schemes	S42_T/TDD/SS/3004
	Typical converter and substation works construction compounds	Onshore Schemes	S42_T/TDD/SS/3005
	Typical OHL pylon detail	Onshore Schemes	S42_T/TDD/SS/3006

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

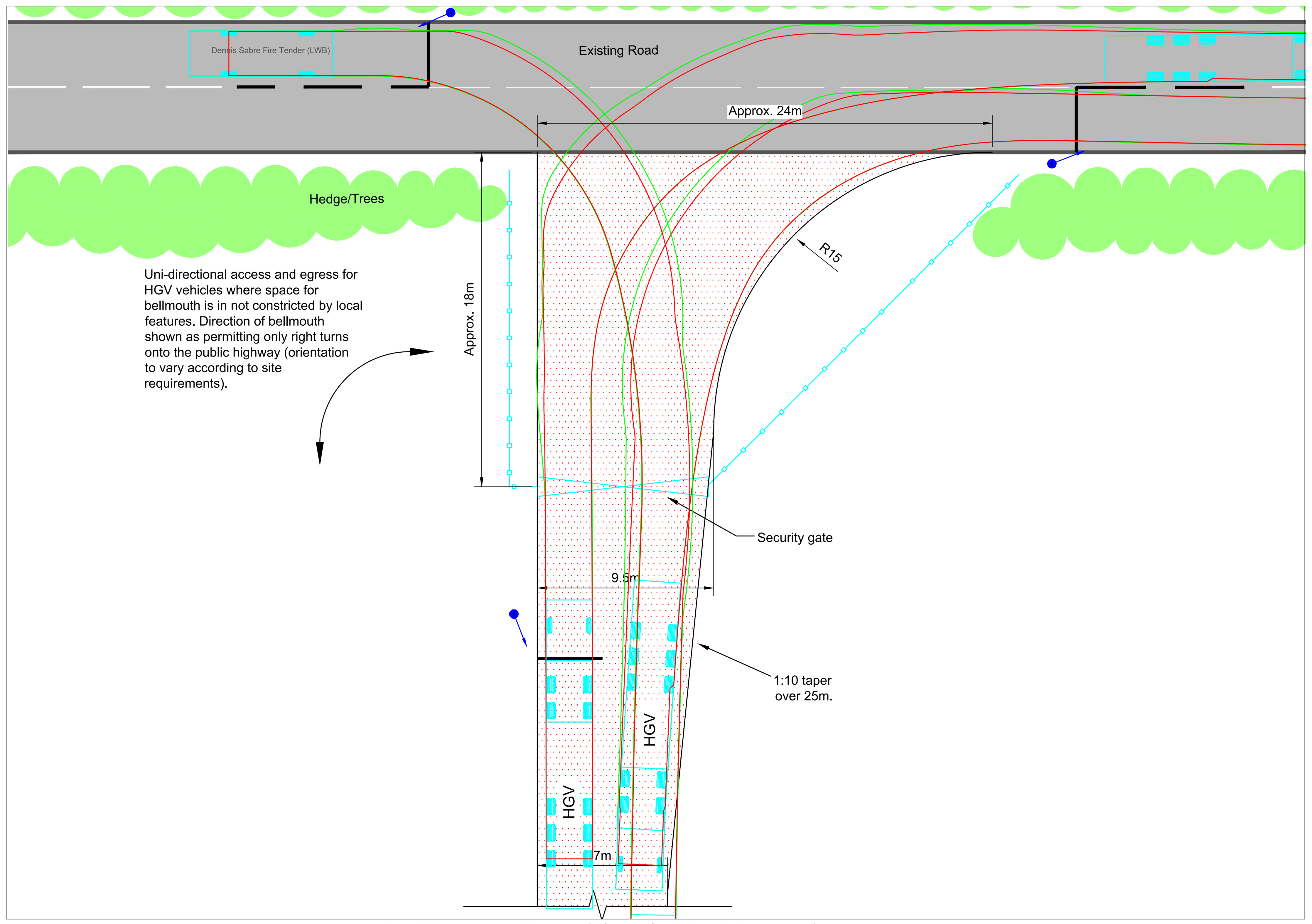
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL BELLMOUTH ARRANGEMENT DETAILS
SHEET 1 OF 1



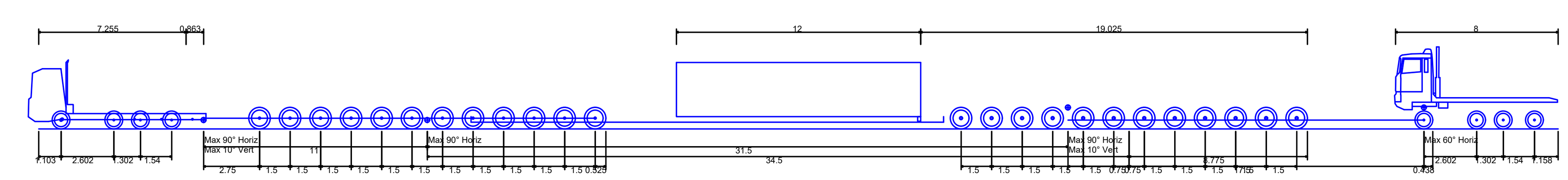
Type 1 Bellmouth - Bi-Directional (HGV and Cable Drum Delivery Vehicle)
1:200



Type 3 Bellmouth - Uni-Directional (AIL)
1:200

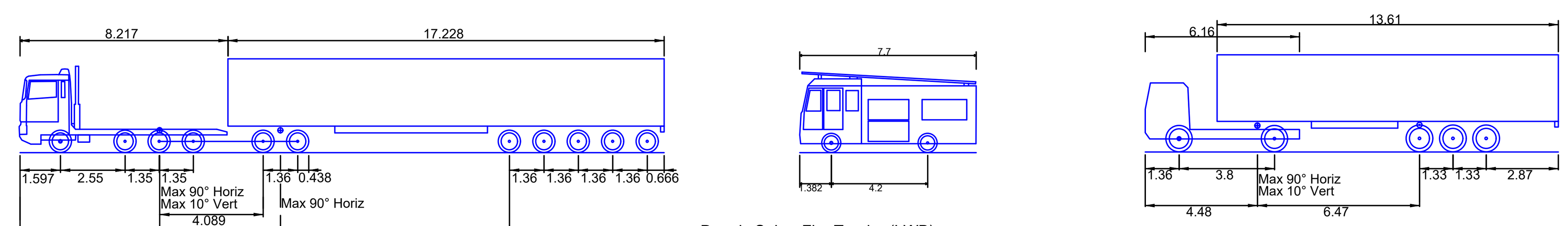


Type 2 Bellmouth - Uni-Directional (HGV and Cable Drum Delivery Vehicle)
1:200



Abnormal Indivisible Load (AIL)- AL50 Girder 12 Axial (with trailer)

Overall Length	74.720m
Overall Width	5.336m
Overall Body Height	4.020m
Min Body Ground Clearance	0.337m
Max Track Width	3.000m
Lock to lock time	6.00s
Wall to Wall Turning Radius	11.550m



CABLE DRUM DELIVERY VEHICLE 25.44m

Overall Length	25.440m
Overall Width	4.500m
Overall Body Height	3.695m
Min Body Ground Clearance	0.332m
Track Width	2.500m
Lock to lock time	6.00s
Kerb to Kerb Turning Radius	14.500m

Dennis Sabre Fire Tender (LWB)

Overall Length	7.700m
Overall Width	2.430m
Overall Body Height	3.512m
Min Body Ground Clearance	0.397m
Track Width	2.380m
Lock to lock time	5.00s
Kerb to Kerb Turning Radius	7.400m

Heavy Goods Vehicle (HGV) DESIGN ARTICULATED VEHICLE (2016)

Overall Length	16.480m
Overall Width	2.550m
Overall Body Height	3.870m
Min Body Ground Clearance	0.515m
Max Track Width	2.470m
Lock to lock time	3.00s
Kerb to Kerb Turning Radius	6.600m

Autotrack Model
NTS

1:200 0 10m 20m

Notes

For statutory consultation purposes only.

These plans show the Draft Order Limits and Draft Cable Alignment and potential pylon locations. Due to the need for future flexibility, National Grid will be applying for Order Limits and Limits of Deviation within its Development Consent Order, within which any final alignment (including pylon locations) would lie. Therefore the Draft Cable Alignment and pylon locations should be treated as indicative only. Further information is provided in our 'Guide to interacting with our consultation plans' document.

For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Legend

- Hedges/Trees
- Temporary 3 or 4 Way Traffic Lights
- Security Gate
- Access Track and Bellmouth
- Security Fence
- Stop Line
- Vehicle total width swept path
- Vehicle wheelbase swept path

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER DESIGN DRAWINGS FOR CONSULTATION

TYPICAL BELLMOUTH ARRANGEMENT DETAILS
SHEET 1 OF 1

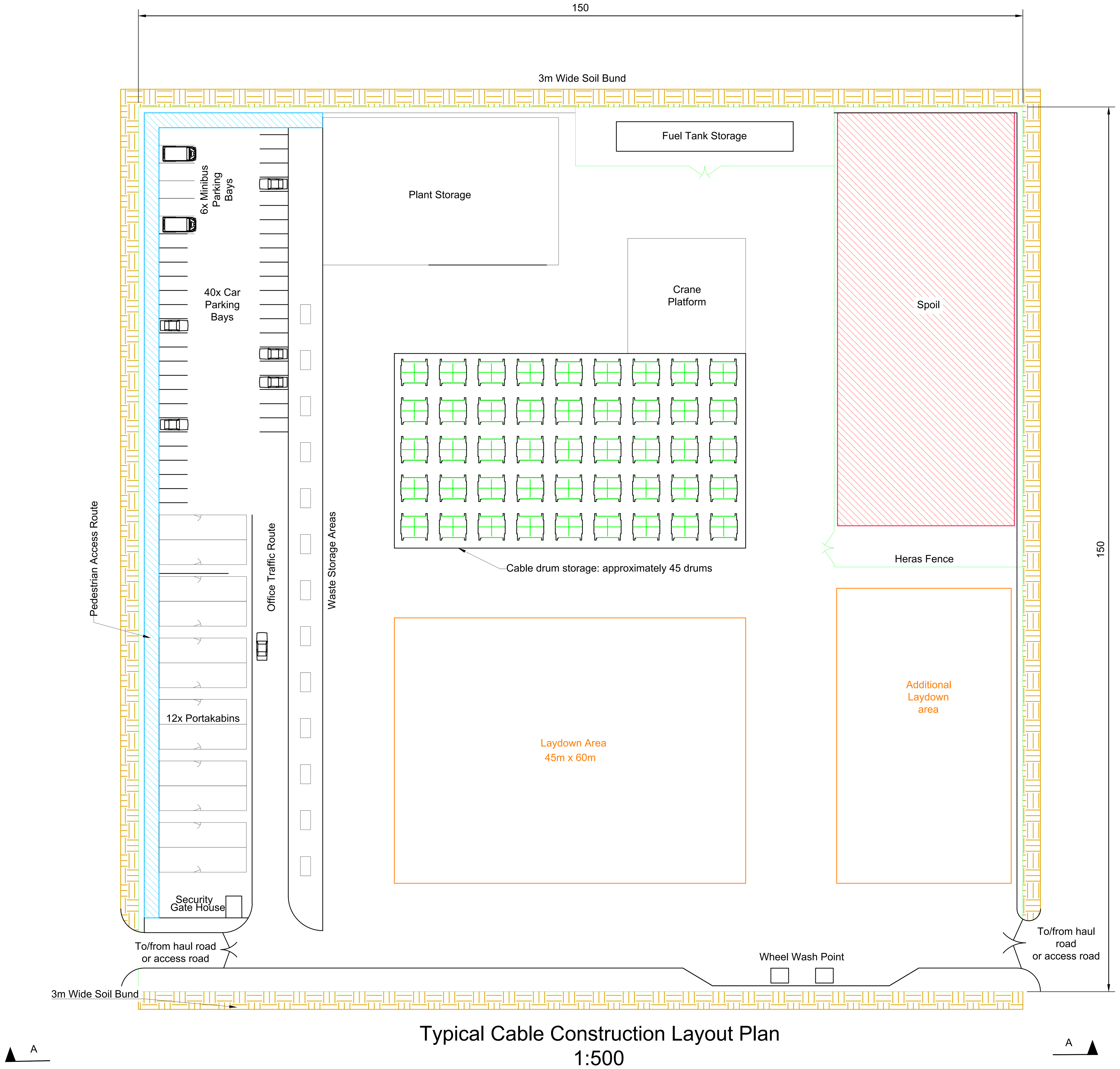
nationalgrid

Application Number
EN020026

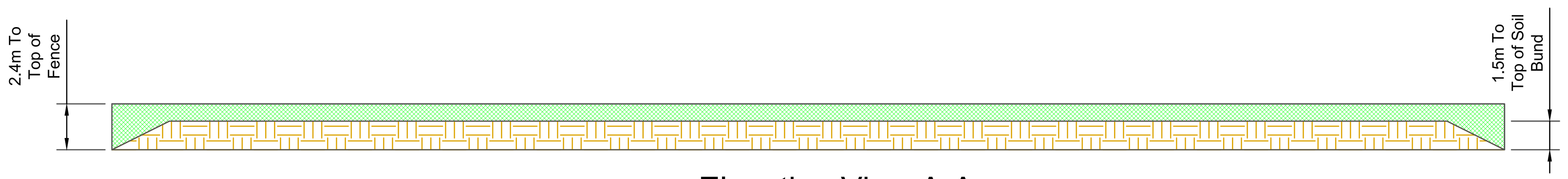
National Grid Drawing Reference
S42_T/TDD/SS/3002

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

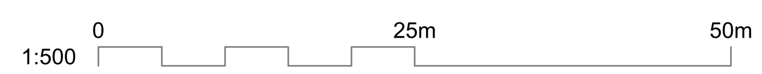
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL OHL AND CONSTRUCTION WORKS CONSTRUCTION COMPOUND
SHEET 1 OF 1



Typical Cable Construction Layout Plan
1:500



Elevation View A-A
1:500



Notes

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Legend

- Pedestrian Access
- Soil Bund
- Spoil
- Laydown Area

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	SC	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL OHL AND CONSTRUCTION WORKS CONSTRUCTION COMPOUND
SHEET 1 OF 1

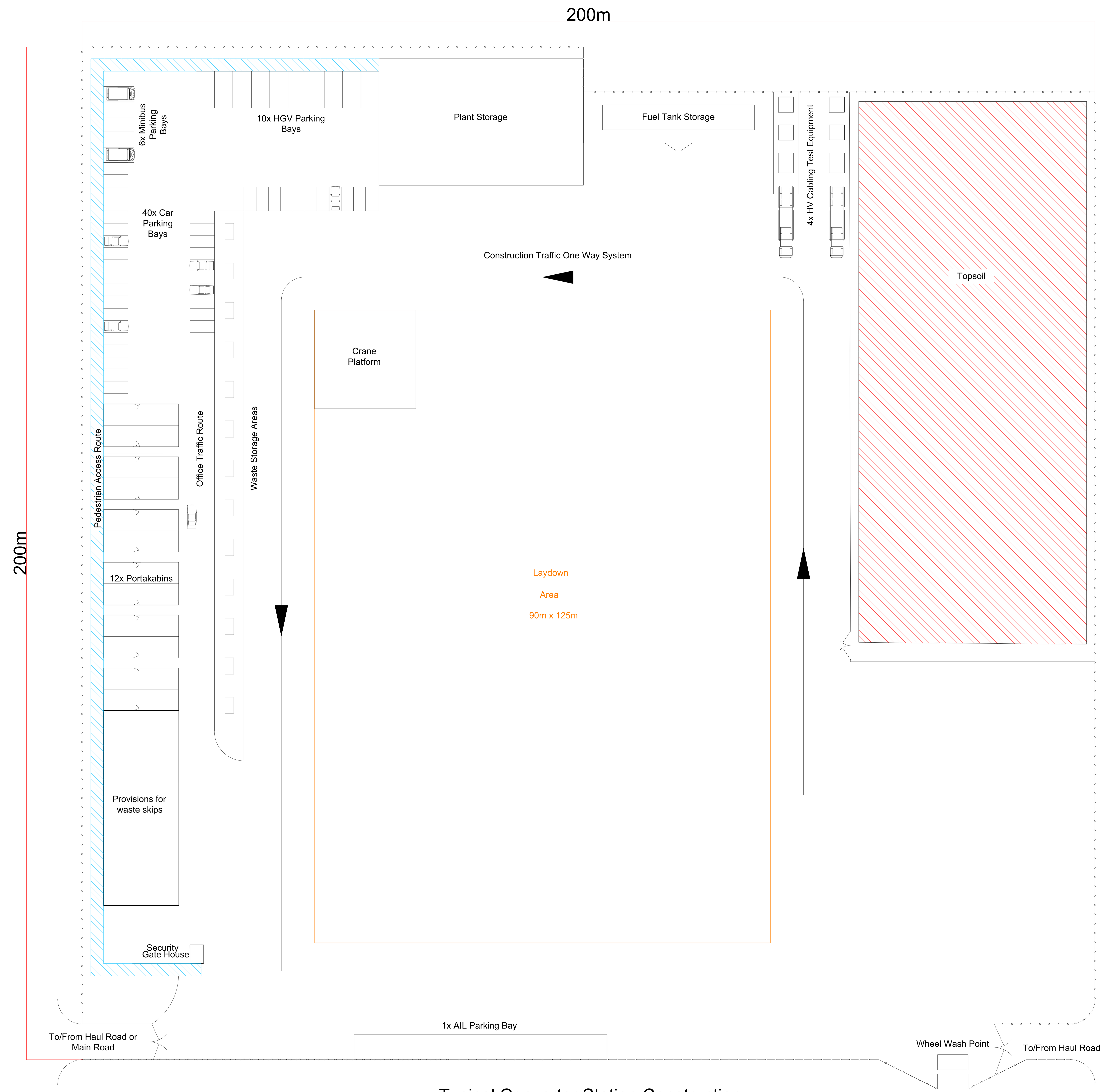
nationalgrid

Application Number: EN020026

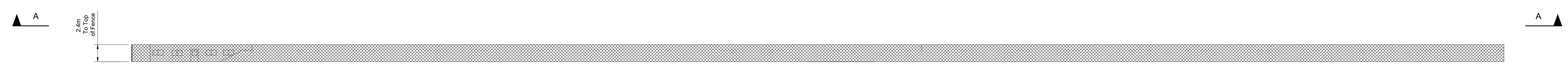
National Grid Drawing Reference: S42_T/TDD/SS/3004

Scale	Sheet Size	Sheet	Issue
As shown	A1	SHEET 1 OF 1	A

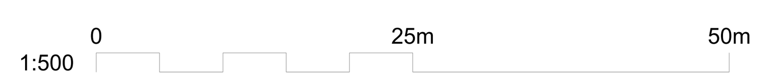
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL CONVERTER AND SUBSTATION WORKS CONSTRUCTION COMPOUNDS
SHEET 1 of 1



Typical Convertor Station Construction Layout Plan



Elevation View A-A



Notes

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2. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

3. Abbreviations
   - AIL - Abnormal Indivisible Loads
   - HGV - Heavy Goods Vehicle
   - HV - High Voltage

Legend

- Pedestrian Access
- Topsoil
- Security Fence

Sheet X Centroid Coordinate: Sheet Y Centroid Coordinate:

A	01/09/2023	FINAL	MS	JW	KJ
Issue	Date	Remarks	Drawn	Checked	Approved

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL CONVERTER AND SUBSTATION WORKS CONSTRUCTION COMPOUNDS
SHEET 1 of 1

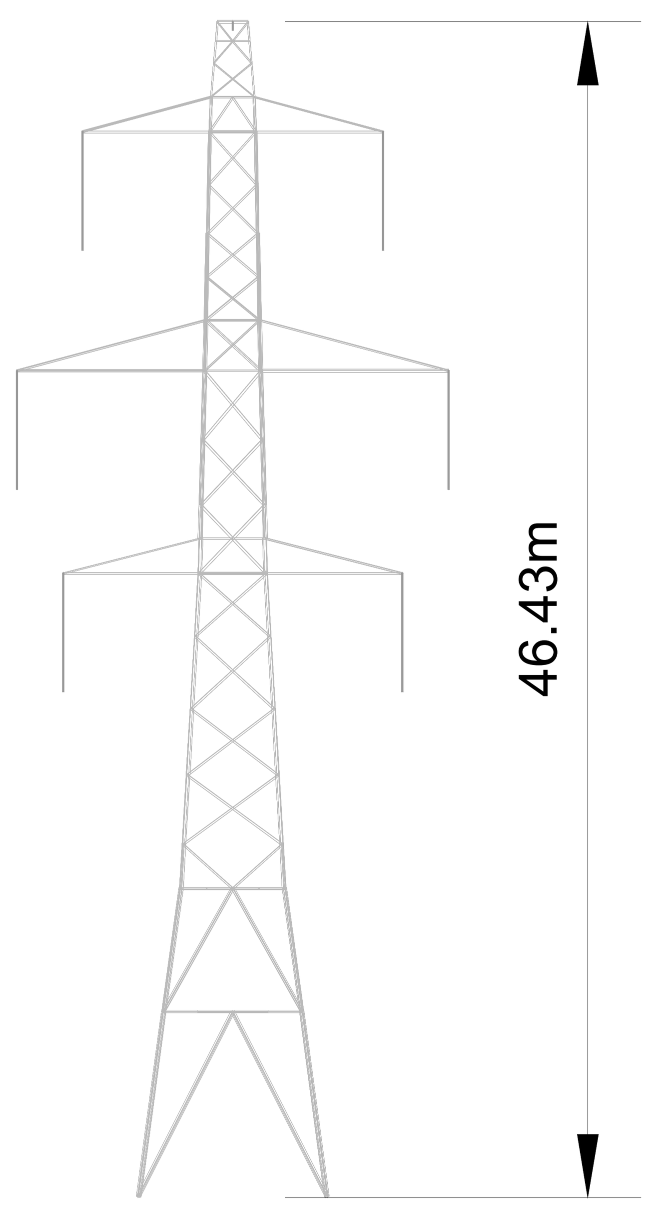
nationalgrid

Application Number
EN020026

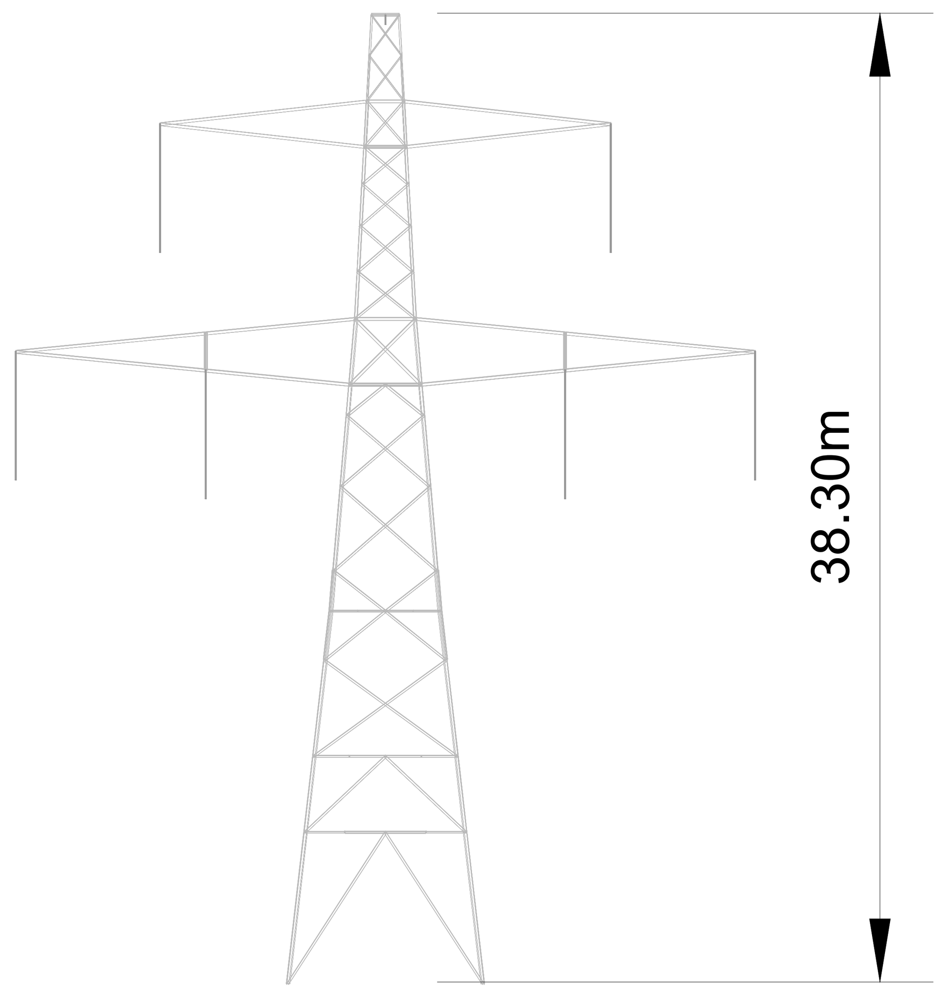
National Grid Drawing Reference
S42_T/TDD/SS/3005

Scale	Sheet Size	Sheet	Issue
AS SHOWN	A1	SHEET 1 OF 1	A

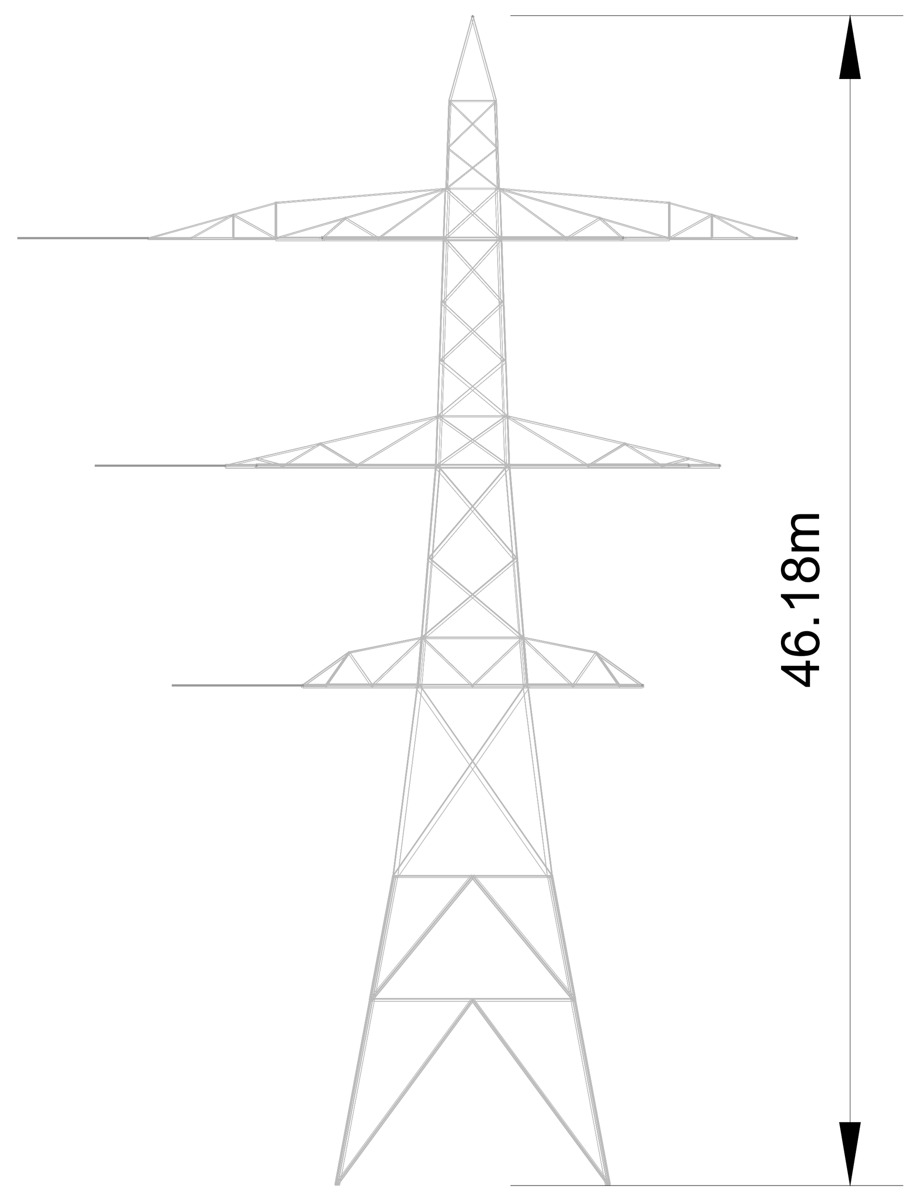
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL OHL PYLON DETAIL
SHEET 1 of 1



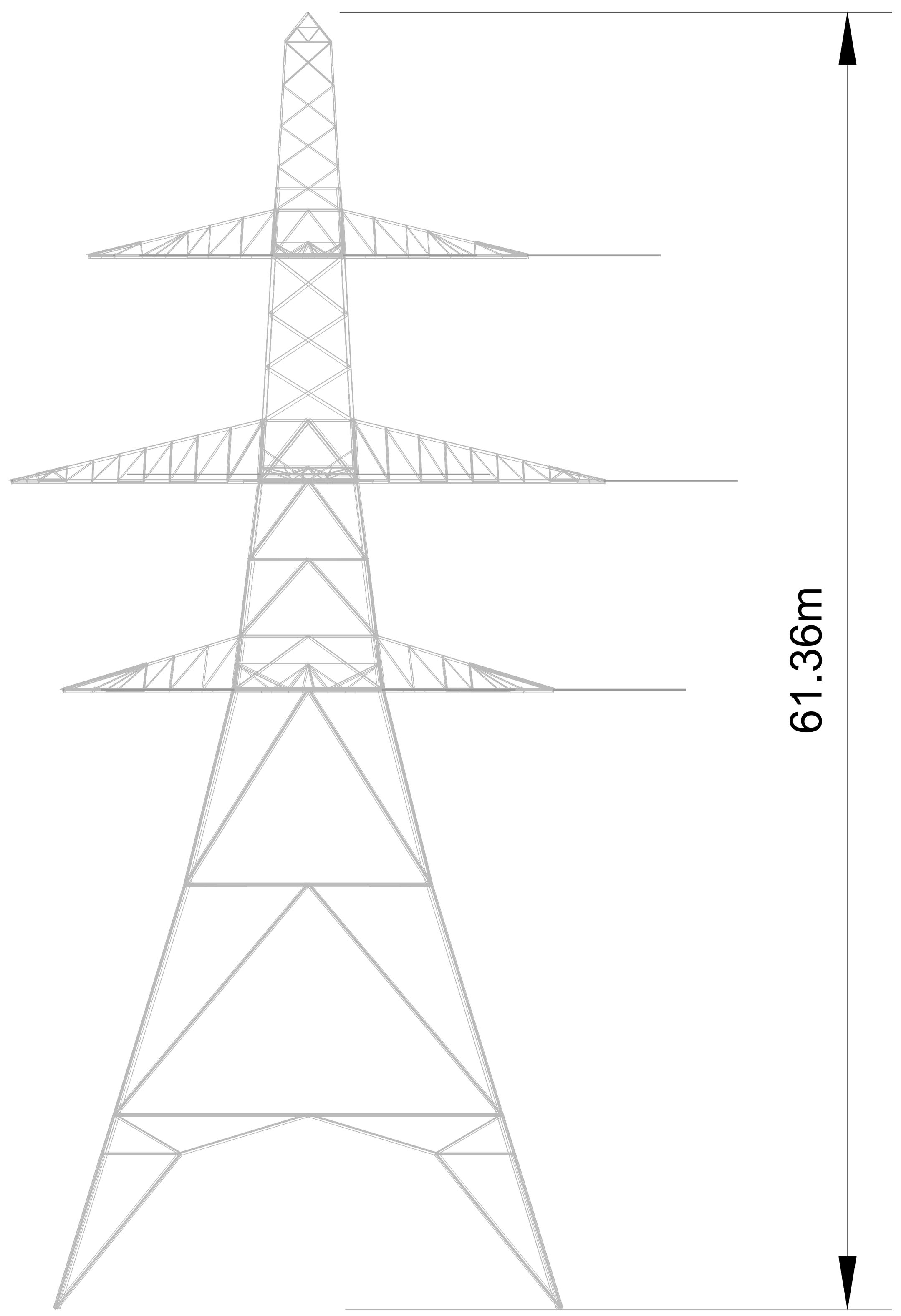
L8 D STD: Suspension Tower



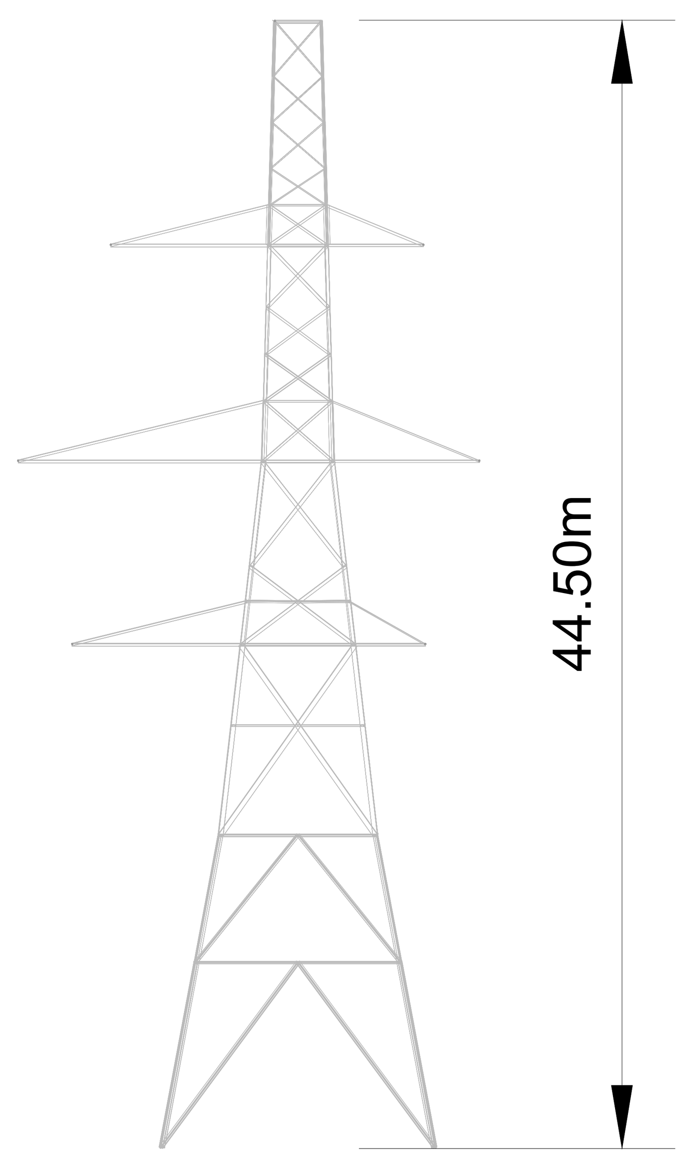
L12 LD E3: Suspension Tower



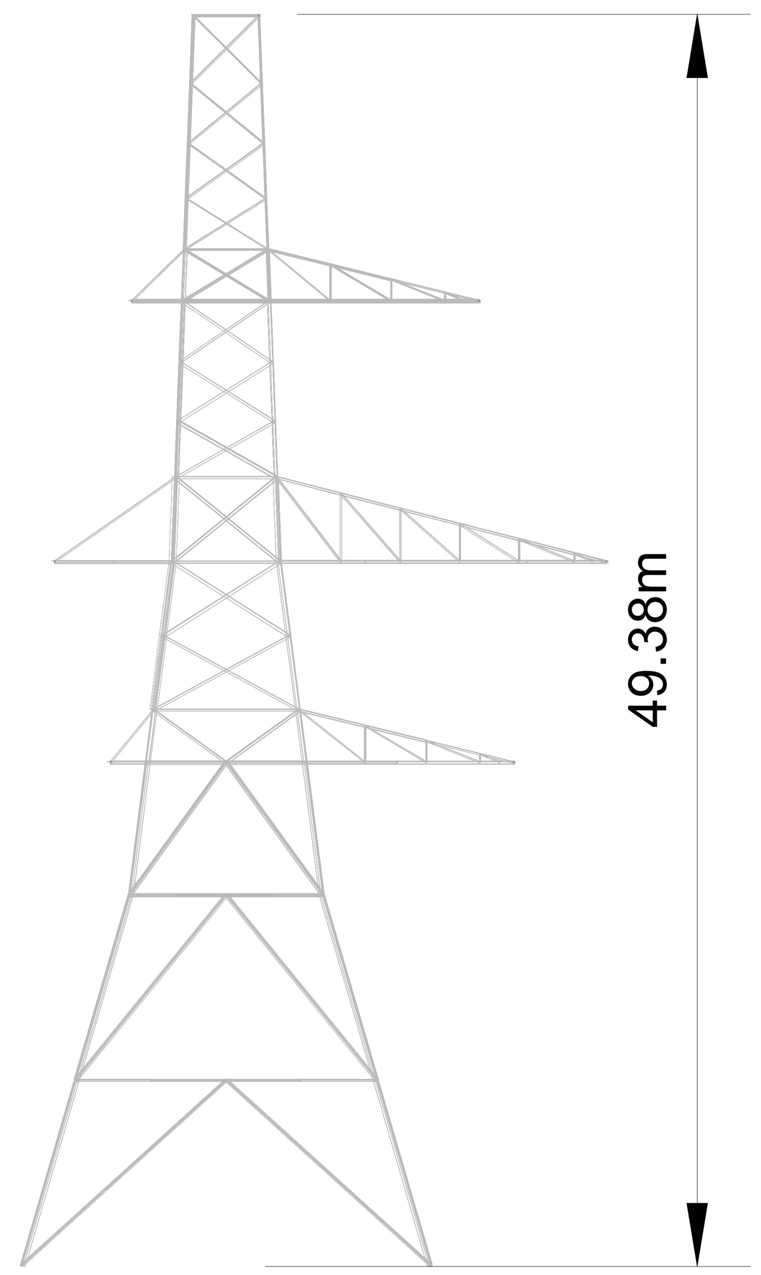
L8 DT STD (Extended Cross Arms): Tension Tower



L6 DJT E3: Tension Tower



L8 D60 STD: Tension Tower



L8 D90 STD: Tension Tower

1:250 0 12.5m 25m

Notes

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For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.

Issue	Date	Remarks	Drawn	Checked	Approved
A	01/09/2023	FINAL	MS	JW	KJ

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
TYPICAL OHL PYLON DETAIL
SHEET 1 of 1

nationalgrid

Application Number
EN020026

National Grid Drawing Reference
S42_T/TDD/SS/3006

Scale	Sheet Size	Sheet	Issue
1:250	A1	SHEET 1 OF 1	A

The Great Grid Upgrade

Sea Link

02. Offshore Design Drawings

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

nationalgrid

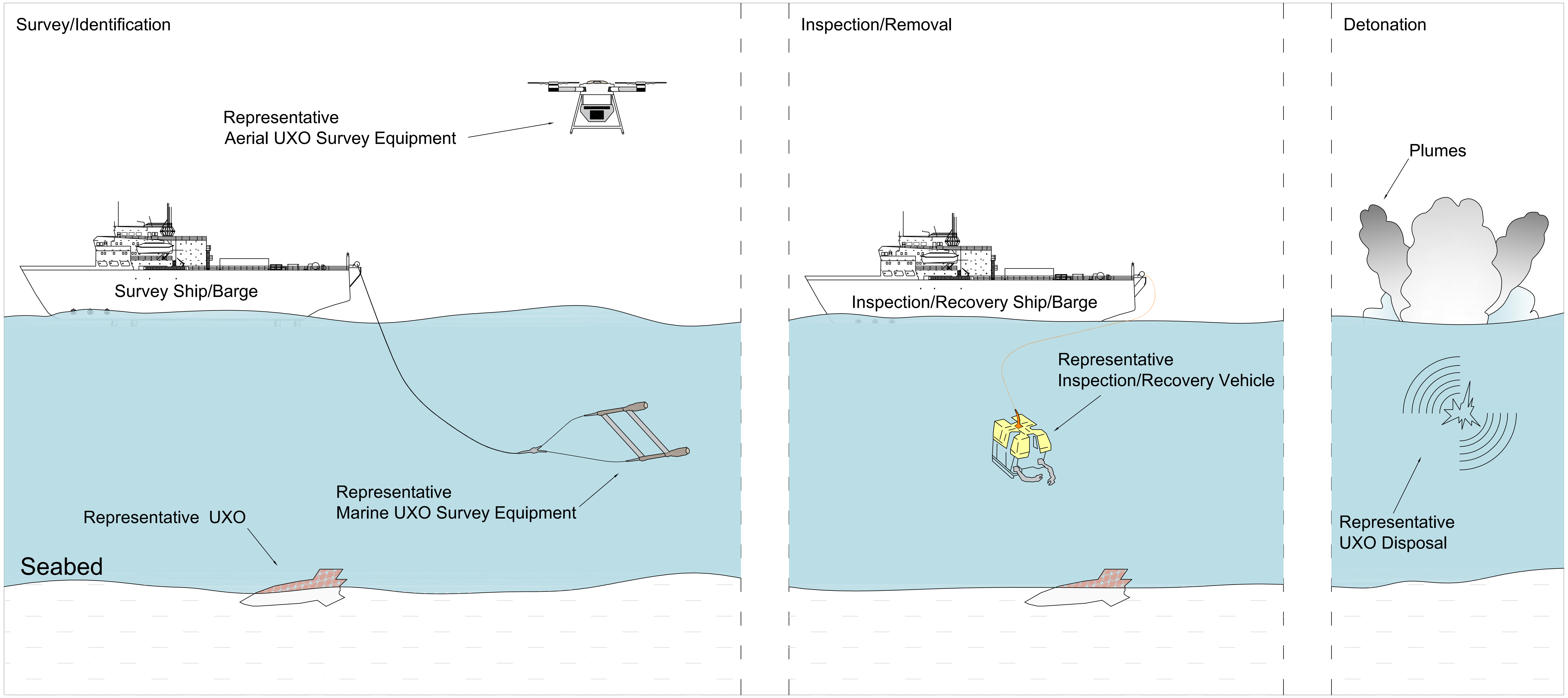
02-01. Pre-Cable Installation Works

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Pre-Cable Installation Works	Illustration of unexploded ordnance, removal and detonation	Offshore Scheme	S42_M/TDD/SS/1030
	Illustration of boulder clearance	Offshore Scheme	S42_M/TDD/SS/1027
	Illustration of pre-lay grapnel run	Offshore Scheme	S42_M/TDD/SS/1028
	Illustration of indicative pre-sweeping and sidecasting	Offshore Scheme	S42_M/TDD/SS/1029

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF
UNEXPLODED ORDNANCE, REMOVAL AND DETONATION
SHEET 1 of 1



Notes
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3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. UXO = Unexploded Ordnance
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend
Water
Seabed Sediment

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
UNEXPLODED ORDNANCE, REMOVAL AND DETONATION
SHEET 1 of 1

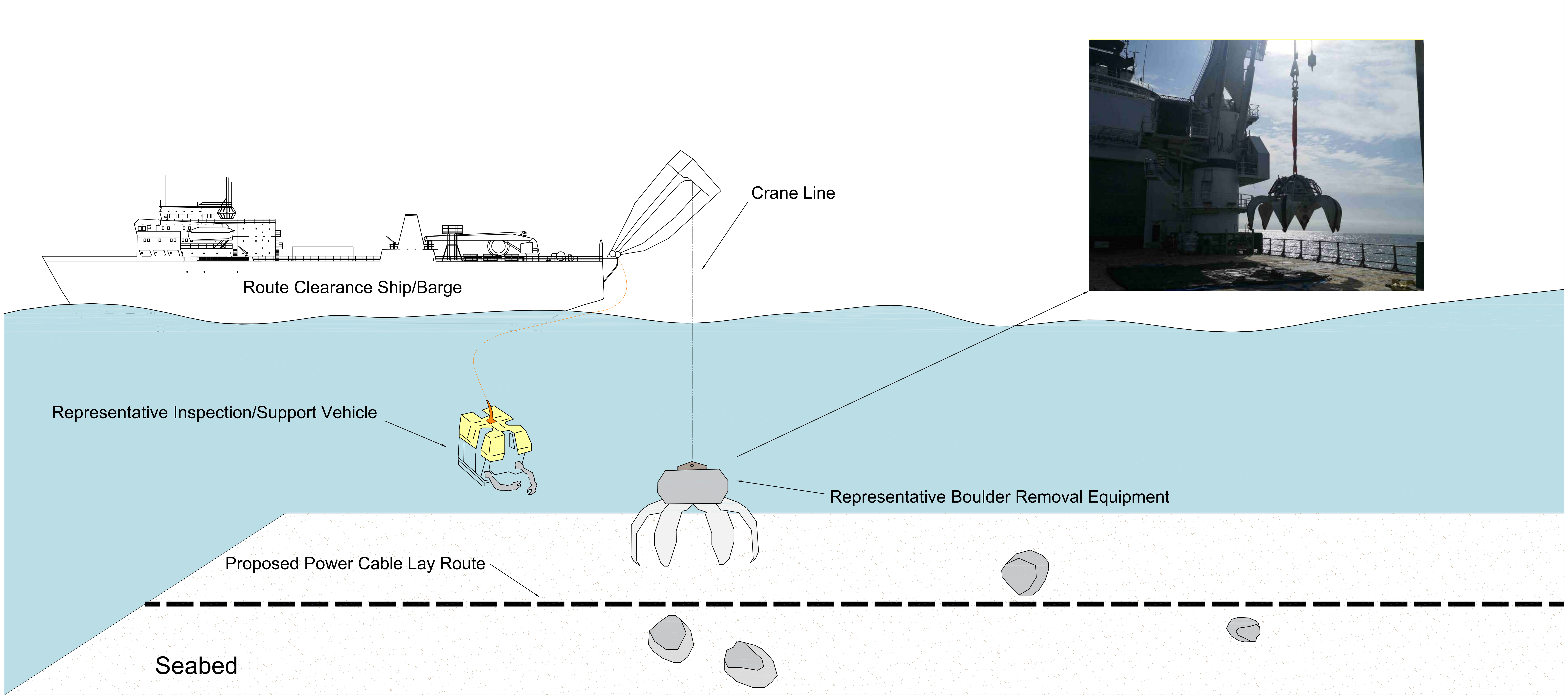
Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1030

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF BOULDER CLEARANCE
SHEET 1 of 1



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7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

Water

Seabed Sediment

Boulder

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

A	24/10/2023	FINAL	AMN	FSS	KG
Issue	Date	Remarks	Drawn	Checked	Approved

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF BOULDER CLEARANCE
SHEET 1 of 1

nationalgrid

Application Number

-

National Grid Drawing Reference

S42_M/TDD/SS/1027

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF
PRE LAY GRAPNEL RUN
SHEET 1 of 1

Notes
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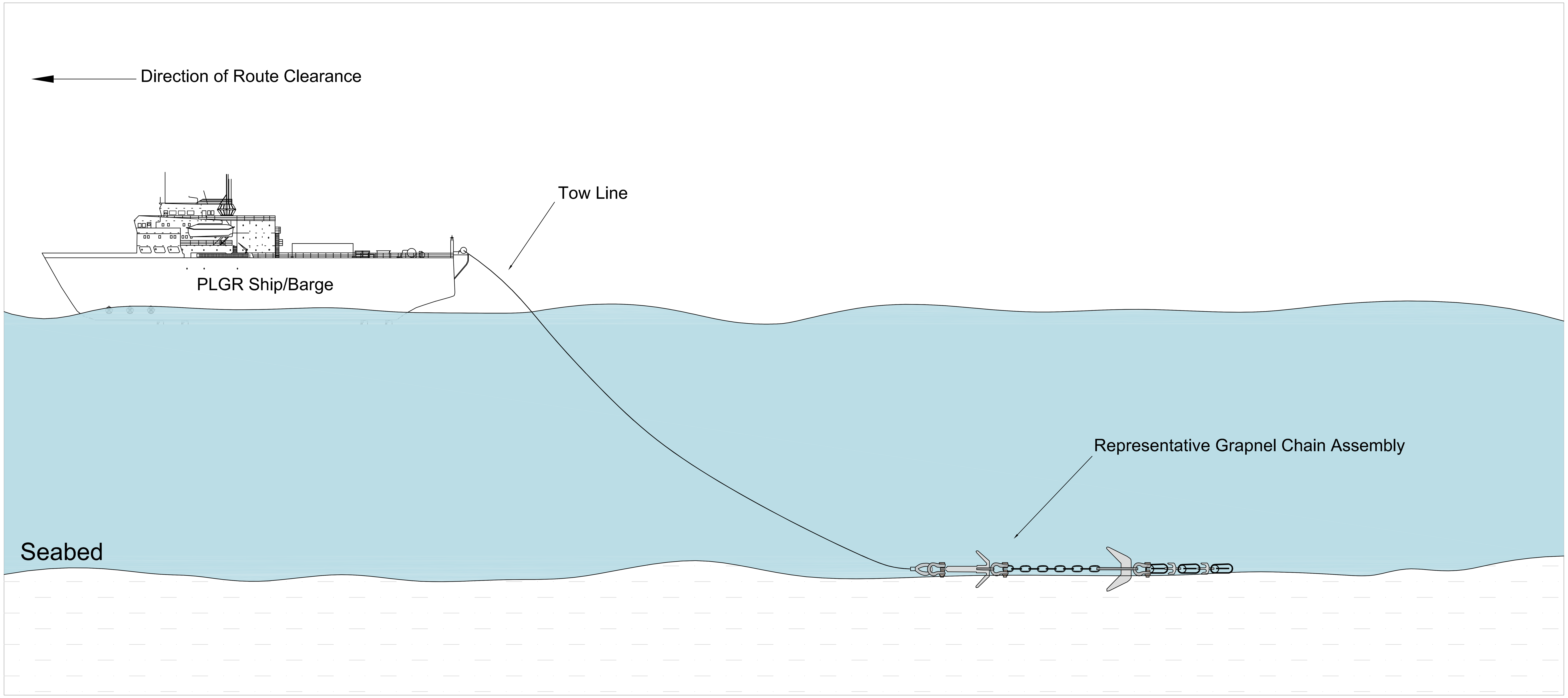
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. PLGR = Pre Lay Grapnel Run
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4



Legend

Water

Seabed Sediment

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
PRE LAY GRAPNEL RUN
SHEET 1 of 1

nationalgrid

Application Number
-

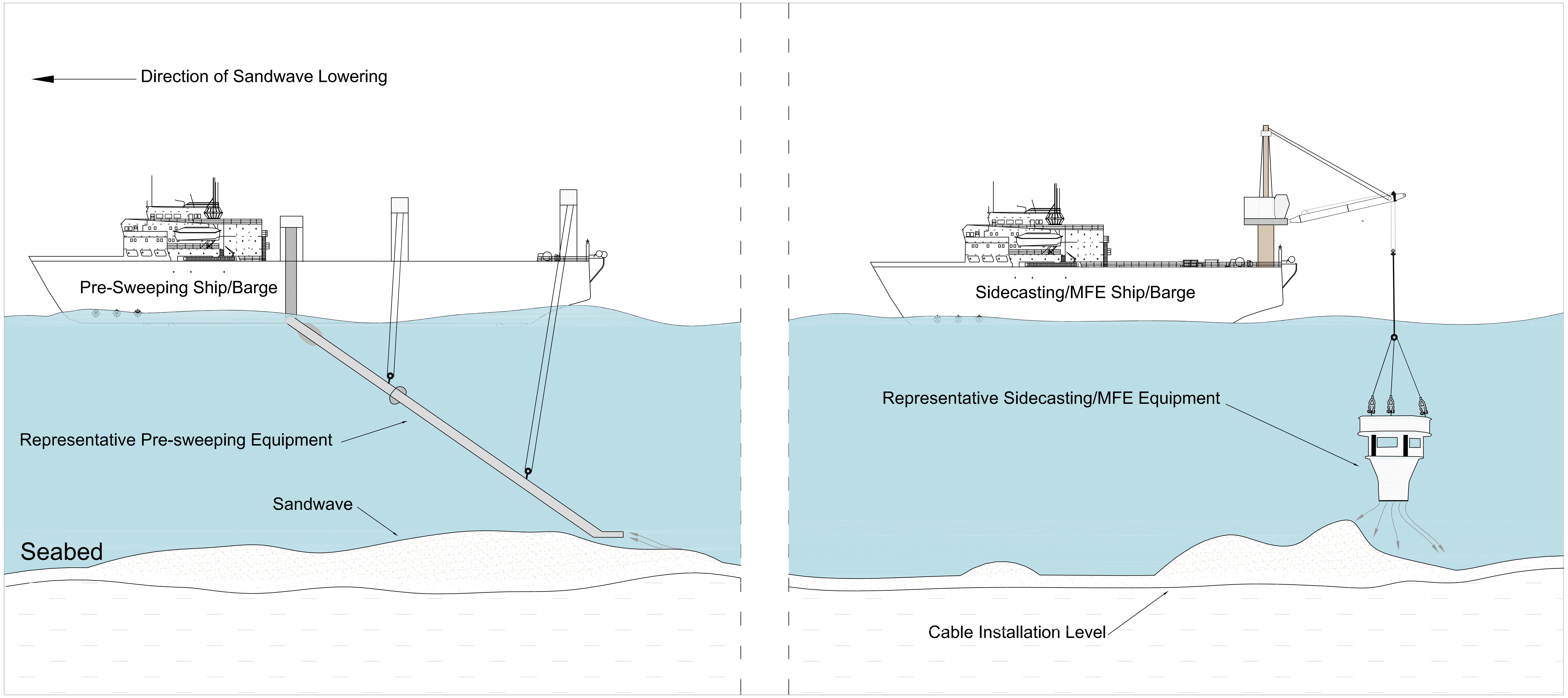
National Grid Drawing Reference
S42_M/TDD/SS/1028

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF INDICATIVE PRE-SWEEPING AND SIDECASTING

SHEET 1 of 1



Notes

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4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. MFE = Mass Flow Excavator.
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

Water

Sandwave

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
INDICATIVE PRE-SWEEPING AND SIDECASTING
SHEET 1 of 1

nationalgrid

Application Number

-

National Grid Drawing Reference

S42_M/TDD/SS/1029

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

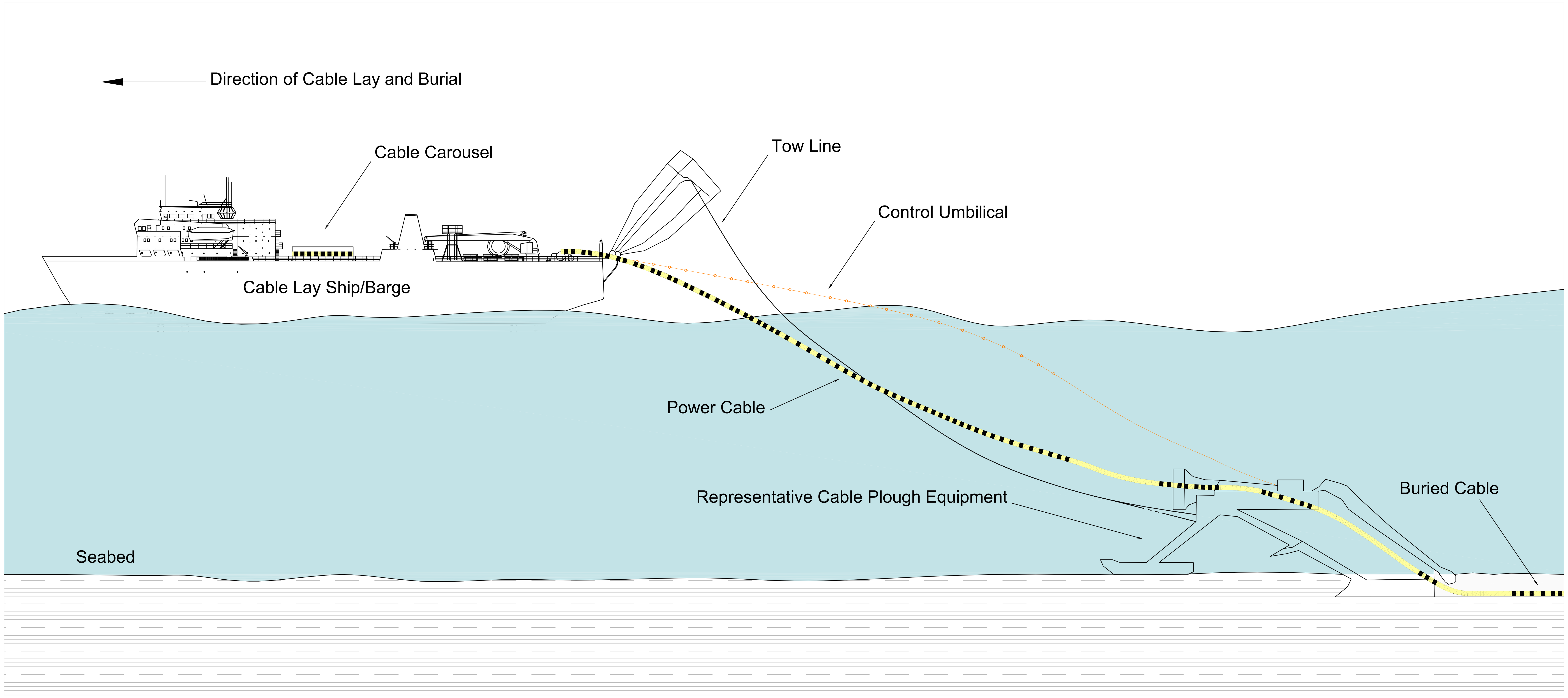
02-02. Cable Installation Works

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Cable Installation Works	Illustration of simultaneous lay and burial	Offshore Scheme	S42_M/TDD/SS/1032
	Illustration of lay and post-lay burial	Offshore Scheme	S42_M/TDD/SS/1033
	Illustration of illustration of omega and inline joint	Offshore Scheme	S42_M/TDD/SS/1031

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF
SIMULTANEOUS LAY AND BURIAL
SHEET 1 of 1



Notes

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7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Water
- Seabed Sediment
- Control Umbilical of Burial Equipment
- Tow Line of Burial Equipment
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
SIMULTANEOUS LAY AND BURIAL
SHEET 1 of 1

nationalgrid

Application Number

-

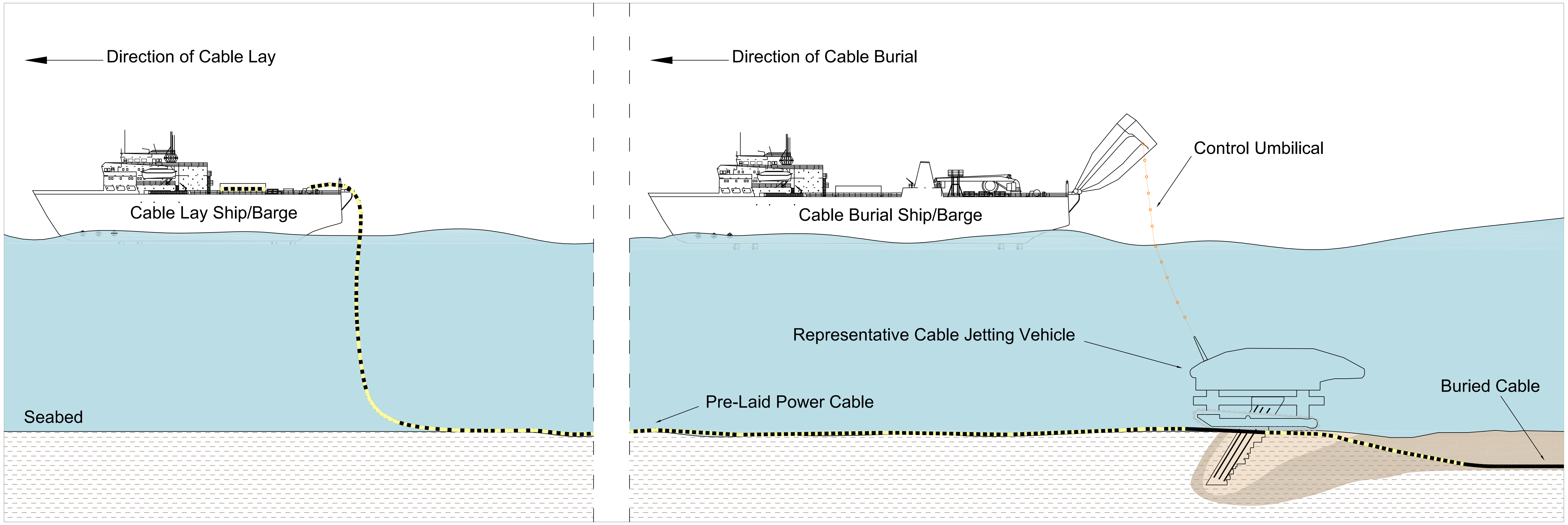
National Grid Drawing Reference

S42_M/TDD/SS/1032

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF
LAY AND POST-LAY BURIAL
SHEET 1 of 1



Notes

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7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Water
- Seabed Sediment
- Fluidization Area
- Sedimentation Area
- Control Umbilical of Burial Equipment
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

A	24/10/2023	FINAL	AMN	FSS	KG
Issue	Date	Remarks	Drawn	Checked	Approved

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
LAY AND POST-LAY BURIAL
SHEET 1 of 1

nationalgrid

Application Number

-

National Grid Drawing Reference

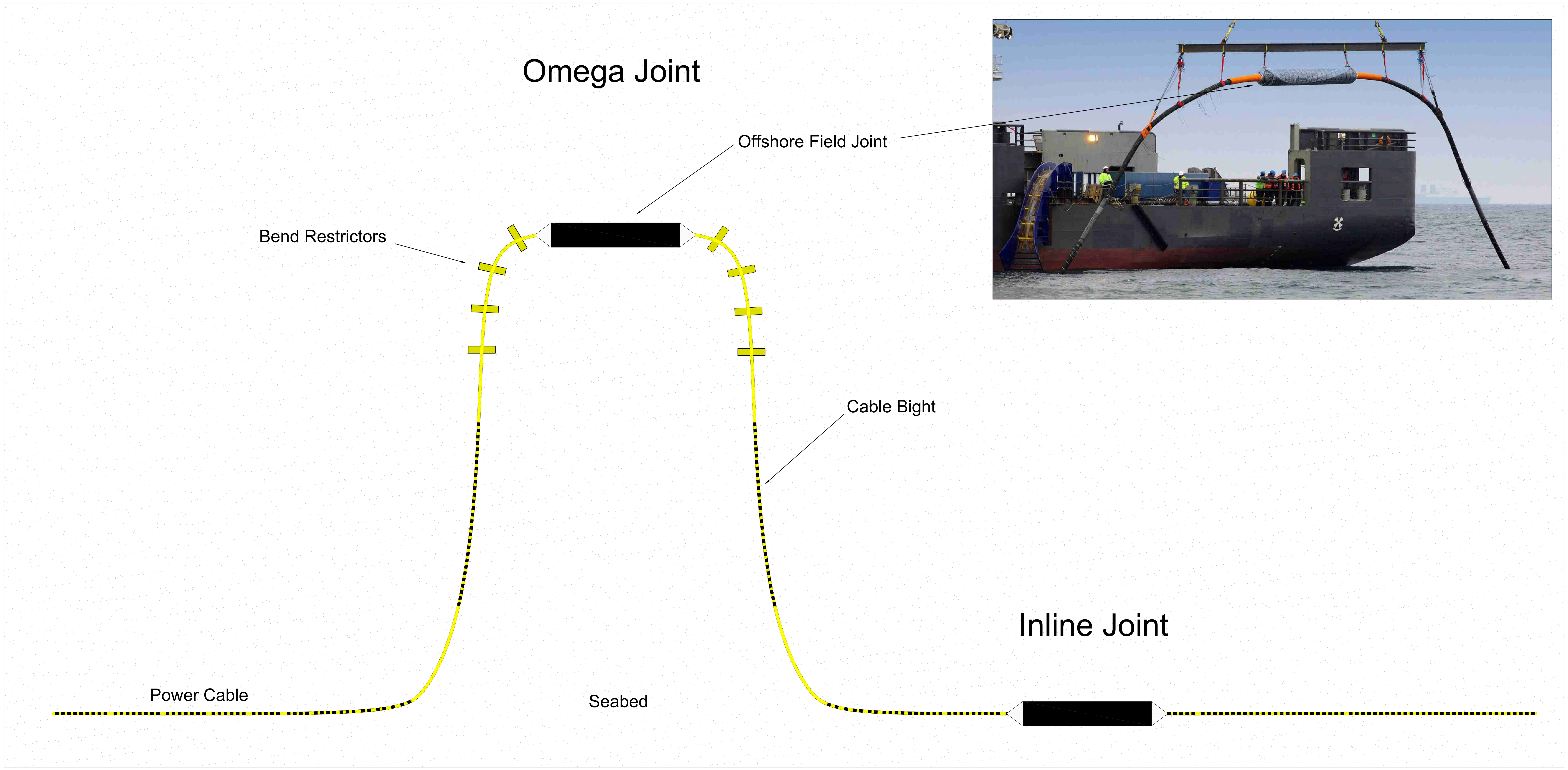
S42_M/TDD/SS/1033

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF OMEGA AND INLINE JOINT

SHEET 1 of 1



Notes

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5. Detailed design, including final dimensions, to be decided at a later date.
6. Infield joint is a joint made on board a cable laying vessel or barge, or in the beach areas, between cable lengths which have been armoured. They are generally used to connect two delivery lengths offshore creating a continuous linear 'in-line' asset.
7. Omega joint is a joint made during cable lay or during a cable repair. The joint get its name because it results in a bight of cable laid to the side of the main cable route and looks like an 'Ω' when viewed from above.
8. For further explanation of these plans see the Guide to the Plans Document.
9. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Seabed Sediment
- New HVDC Bundle
- Inline/Omega Joint

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
OMEGA AND INLINE JOINT
SHEET 1 of 1

nationalgrid

Application Number

-

National Grid Drawing Reference

S42_M/TDD/SS/1031

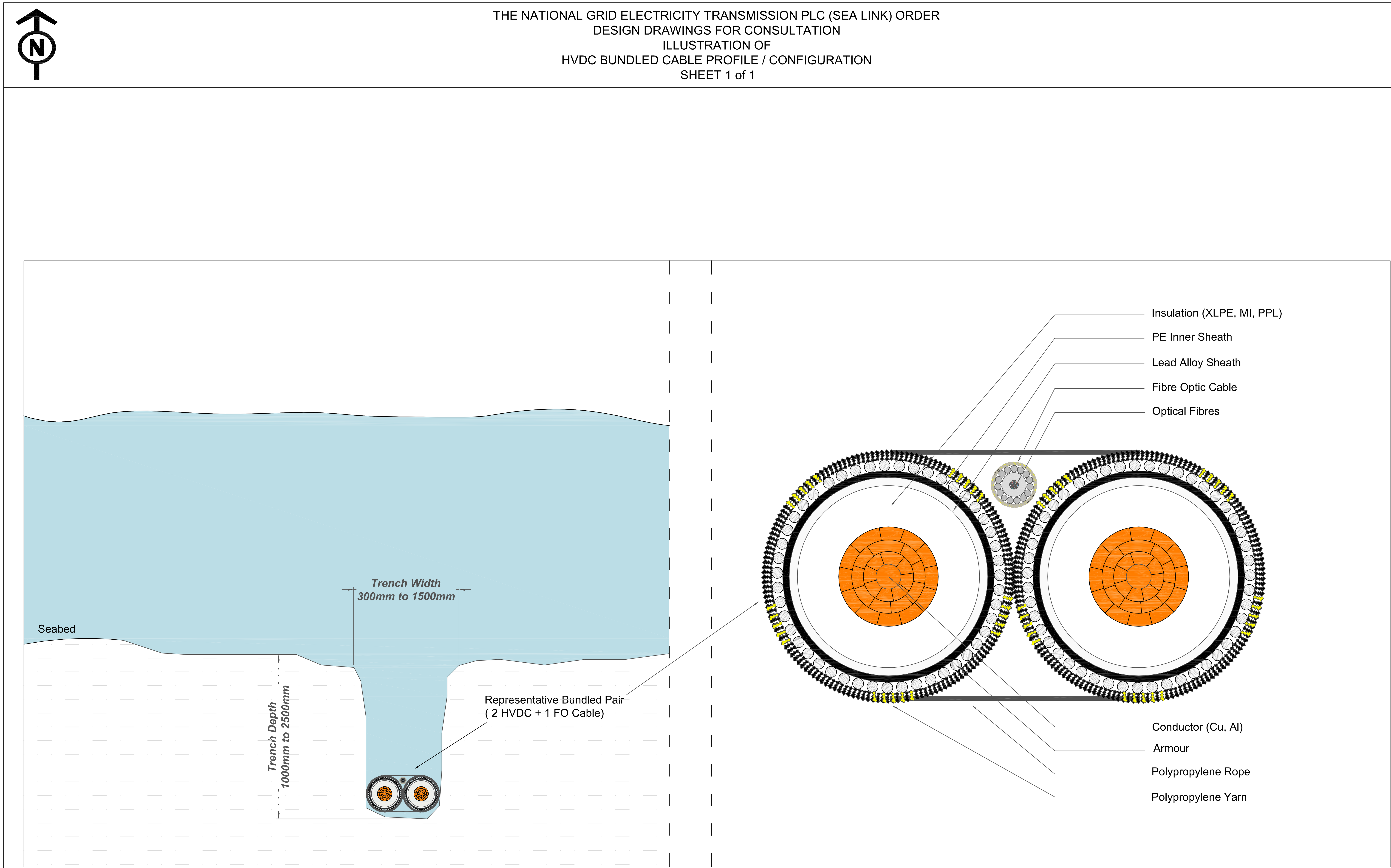
Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

02-03. Cable Configuration and Trench Profiles

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Cable Configuration and Trench Profiles	Illustration of bundled cable profile/ configuration	Offshore Scheme	S42_M/TDD/SS/1026
	Illustration of typical marine trench profiles	Offshore Scheme	S42_M/TDD/SS/1036

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
HVDC BUNDLED CABLE PROFILE / CONFIGURATION
SHEET 1 of 1



Notes
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4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. The possibility of 'V' shaped trench due to shallow soil types and/or trench collapse cannot be ruled out.
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Water
- Sub-seabed Sediment

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
HVDC BUNDLED CABLE PROFILE / CONFIGURATION
SHEET 1 of 1

nationalgrid

Application Number
-

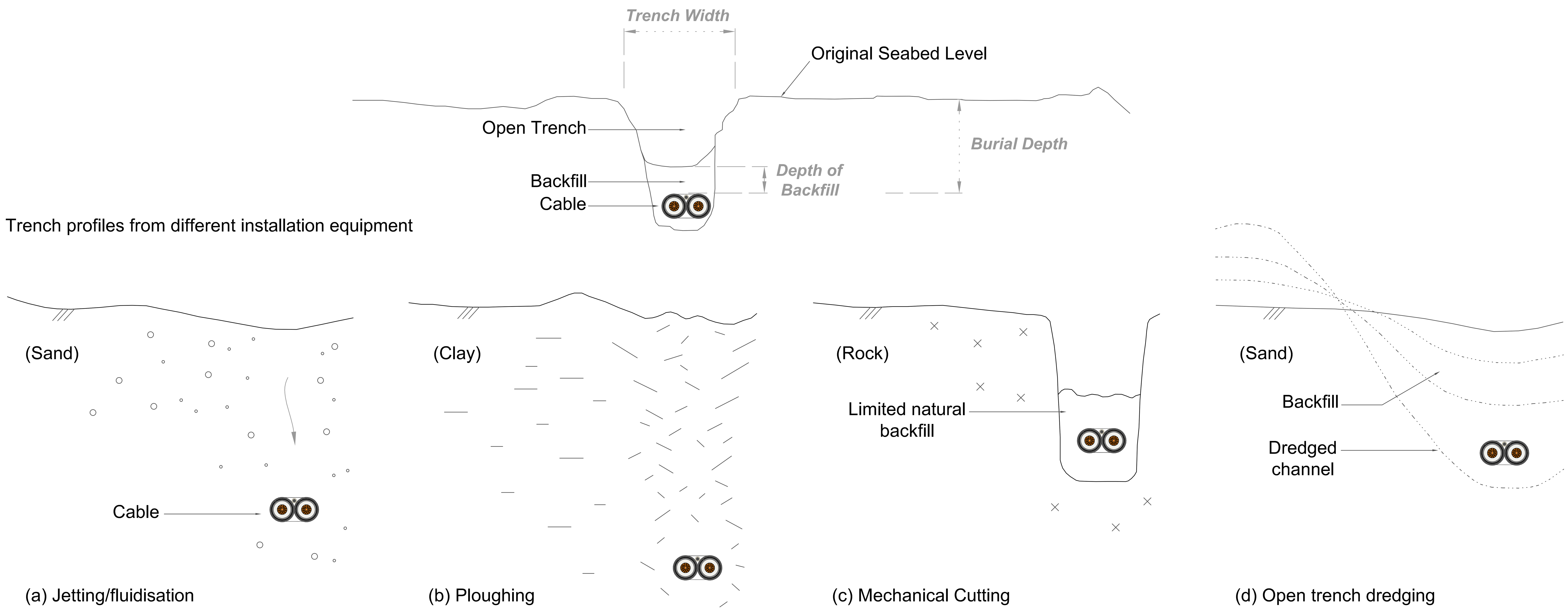
National Grid Drawing Reference
S42_M/TDD/SS/1026

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

ILLUSTRATION OF TYPICAL MARINE TRENCH PROFILES
SHEET 1 of 1

Notes
For statutory consultation purposes only
1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Typical Trench Profile



(after: Subsea power cables in shallow water, DNVGL-RP-0360)

Legend

Sheet X Centroid Coordinate: N/A | Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
TYPICAL MARINE TRENCH PROFILES
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1036

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

02-04. Cable Crossings and Protection

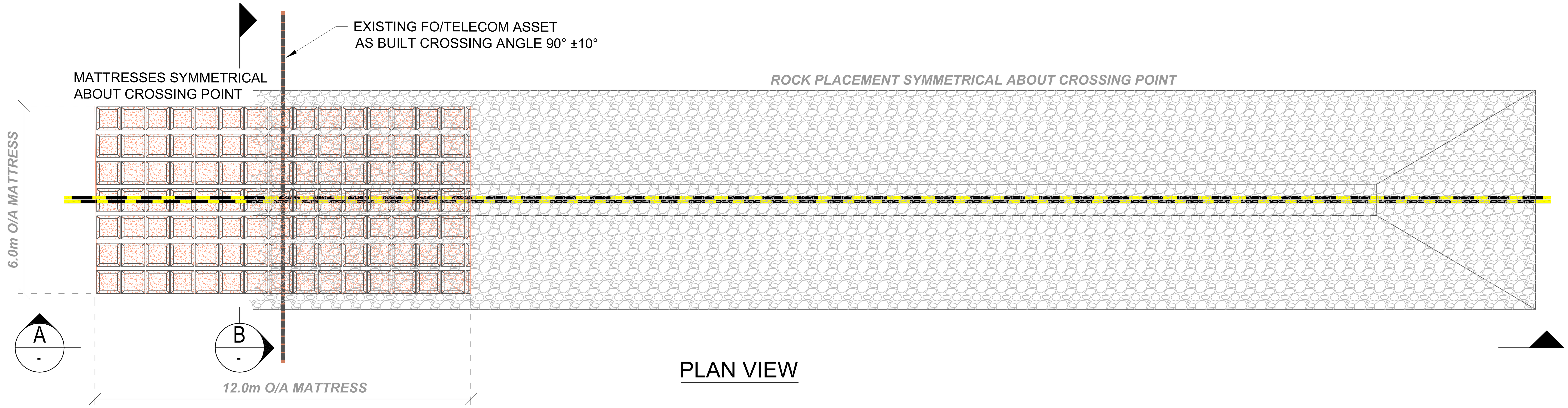
Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Cable Crossings and Protection	Indicative HVDC bundled cable crossing over unburied fibre optic/telecoms asset	Offshore Scheme	S42_M/TDD/SS/1021
	Indicative HVDC bundled cable crossing over buried FO/telecoms asset	Offshore Scheme	S42_M/TDD/SS/1022
	Indicative HVDC bundled cable crossing over buried power cable asset	Offshore Scheme	S42_M/TDD/SS/1023
	Indicative HVDC bundled cable crossing over pre lay berm	Offshore Scheme	S42_M/TDD/SS/1024
	Indicative rock berm schematics pre lay and post lay	Offshore Scheme	S42_M/TDD/SS/1025
	Illustration of cable protective systems	Offshore Scheme	S42_M/TDD/SS/1034
	Illustration of rock placement sections	Offshore Scheme	S42_M/TDD/SS/1035

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

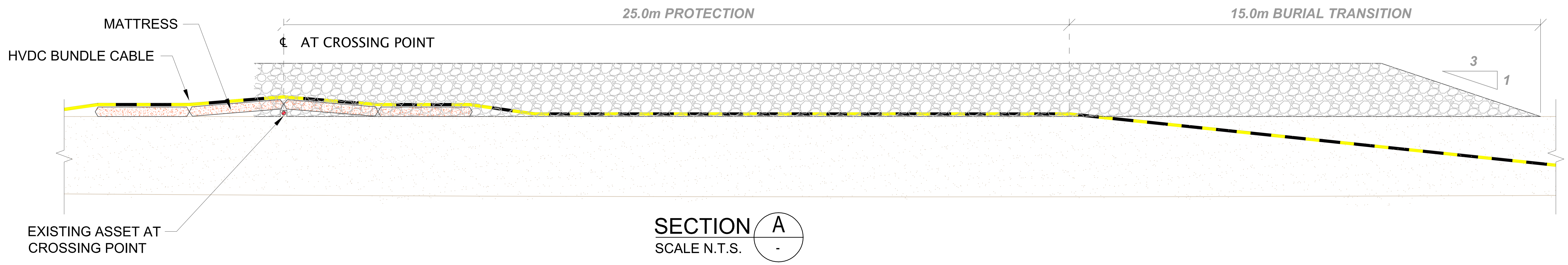
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HVDC BUNDLED CABLE CROSSING OVER UNBURIED FO/TELECOMS ASSET

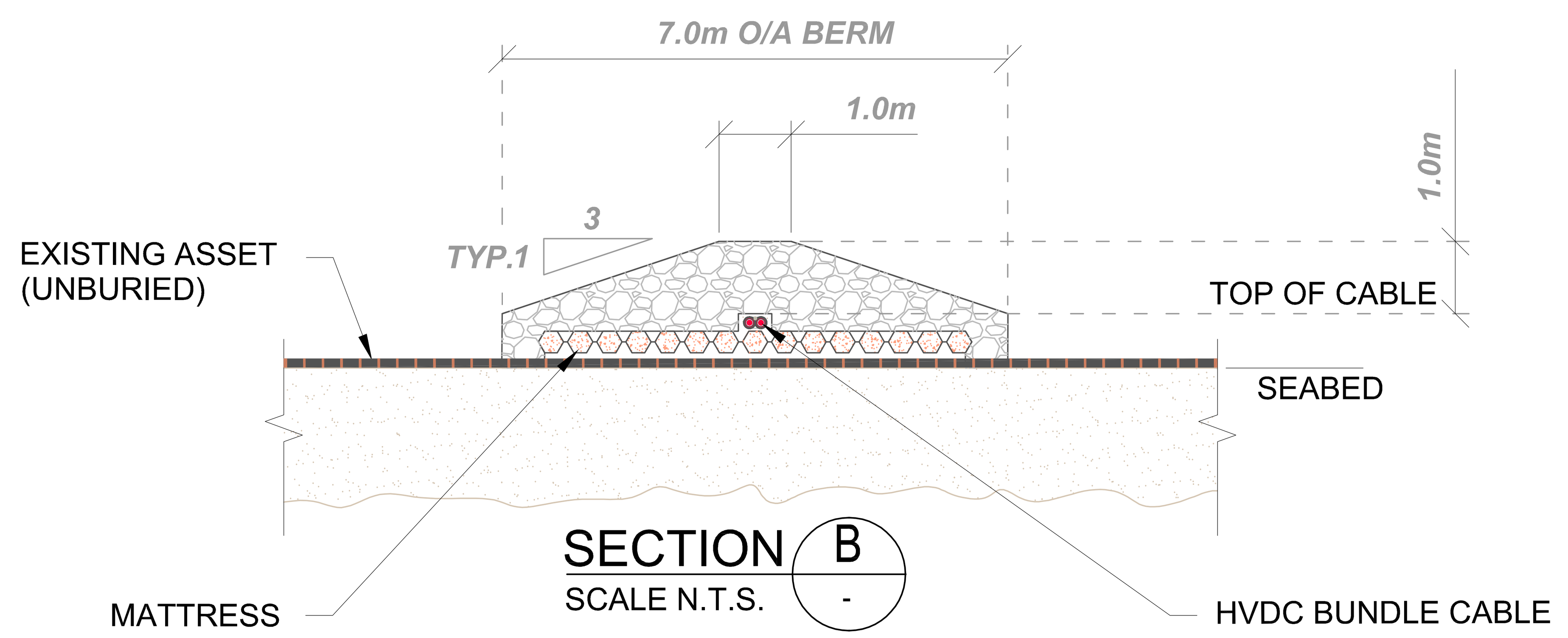
SHEET 1 of 1



PLAN VIEW



SECTION A
SCALE N.T.S.



SECTION B
SCALE N.T.S.

Notes

For statutory consultation purposes only

1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Post Lay Rock Berm
- Mattress (Plan View)
- Mattress (Section A)
- Mattress (Section B)
- Existing Asset
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER UNBURIED FO/TELECOMS ASSET
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1021

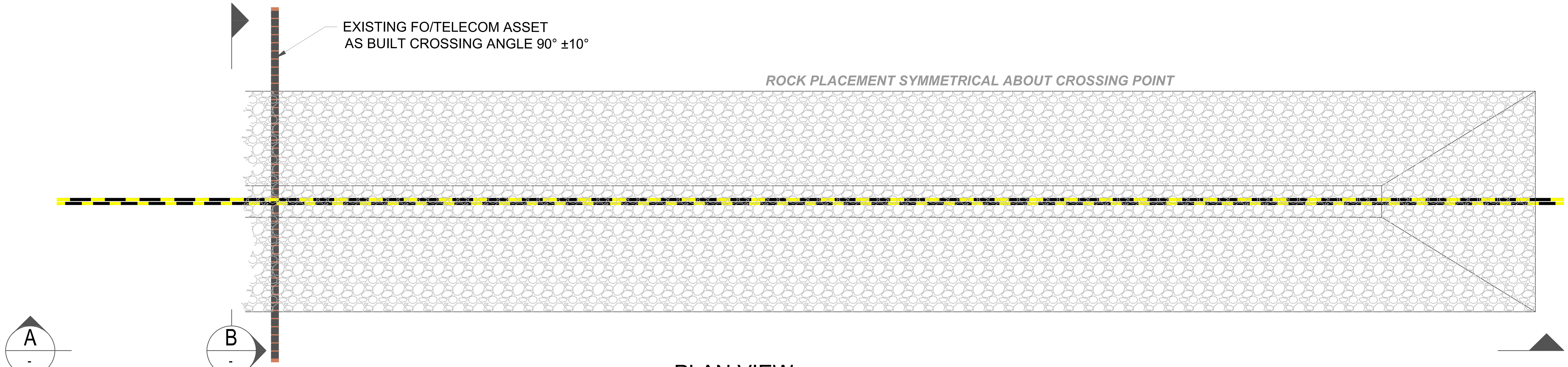
Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER BURIED FO/TELECOMS ASSET
SHEET 1 of 1

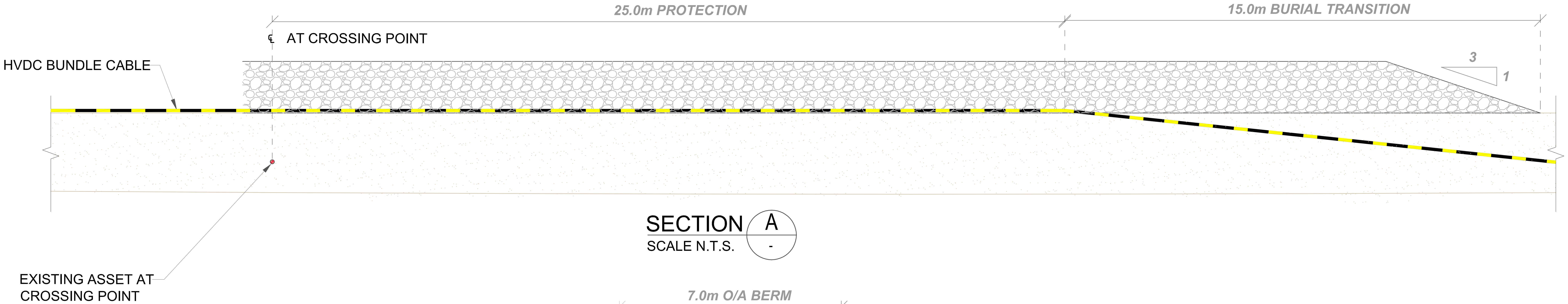
Notes

For statutory consultation purposes only

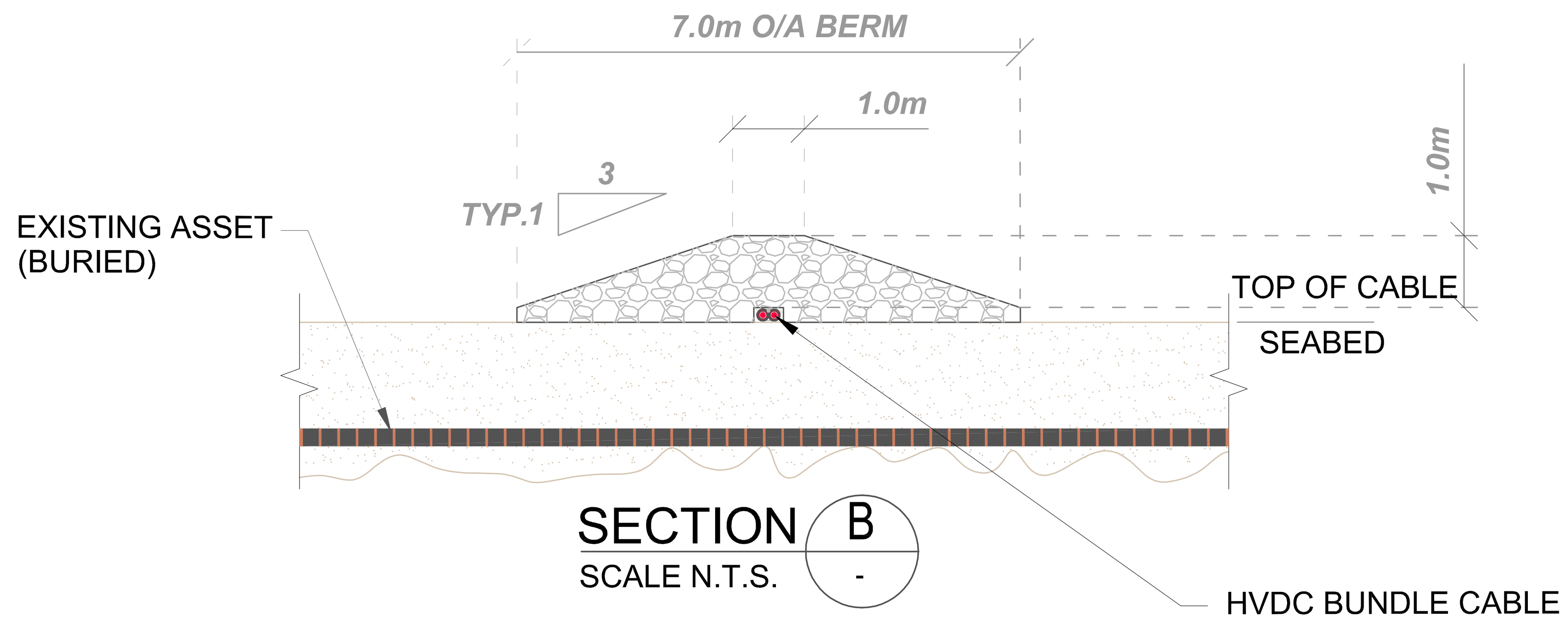
1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4



PLAN VIEW



SECTION A
SCALE N.T.S.



SECTION B
SCALE N.T.S.

Legend

- Post Lay Rock Berm
- Existing Asset
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER BURIED FO/TELECOMS ASSET
SHEET 1 of 1

nationalgrid

Application Number

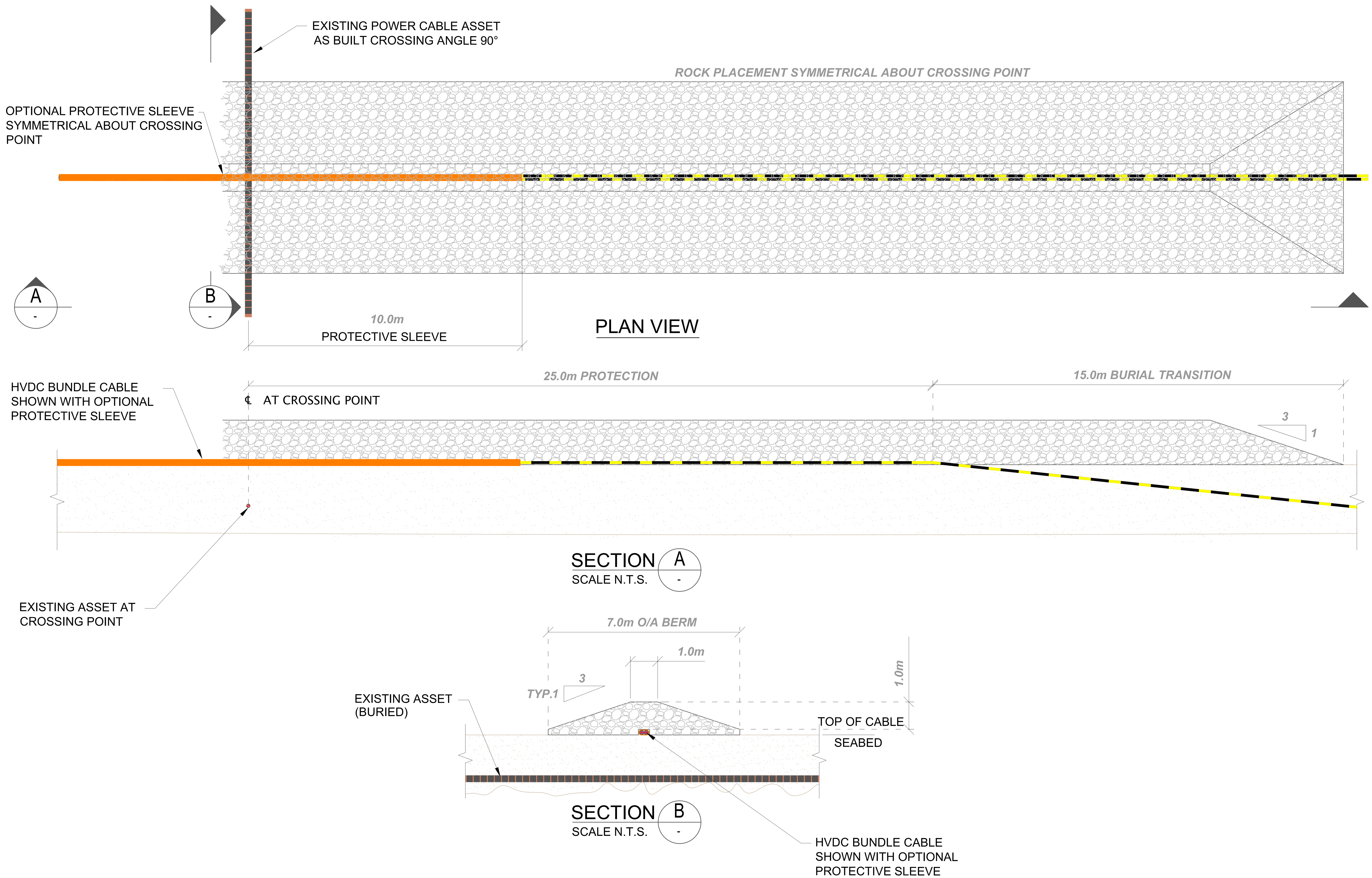
-

National Grid Drawing Reference

S42_M/TDD/SS/1022

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER BURIED POWER CABLE ASSET
SHEET 1 of 1



Notes

For statutory consultation purposes only

1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. Minimum vertical offset between the crossing power cables to be agreed as part of crossing agreement.
7. Protective sleeves can be added ±10m from crossing point, if required as part of crossing agreement.
8. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Post Lay Rock Berm
- Existing Asset
- New HVDC Bundle
- Protective Sleeve

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER BURIED POWER CABLE ASSET
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1023

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER PRE LAY BERM
SHEET 1 of 1

Notes

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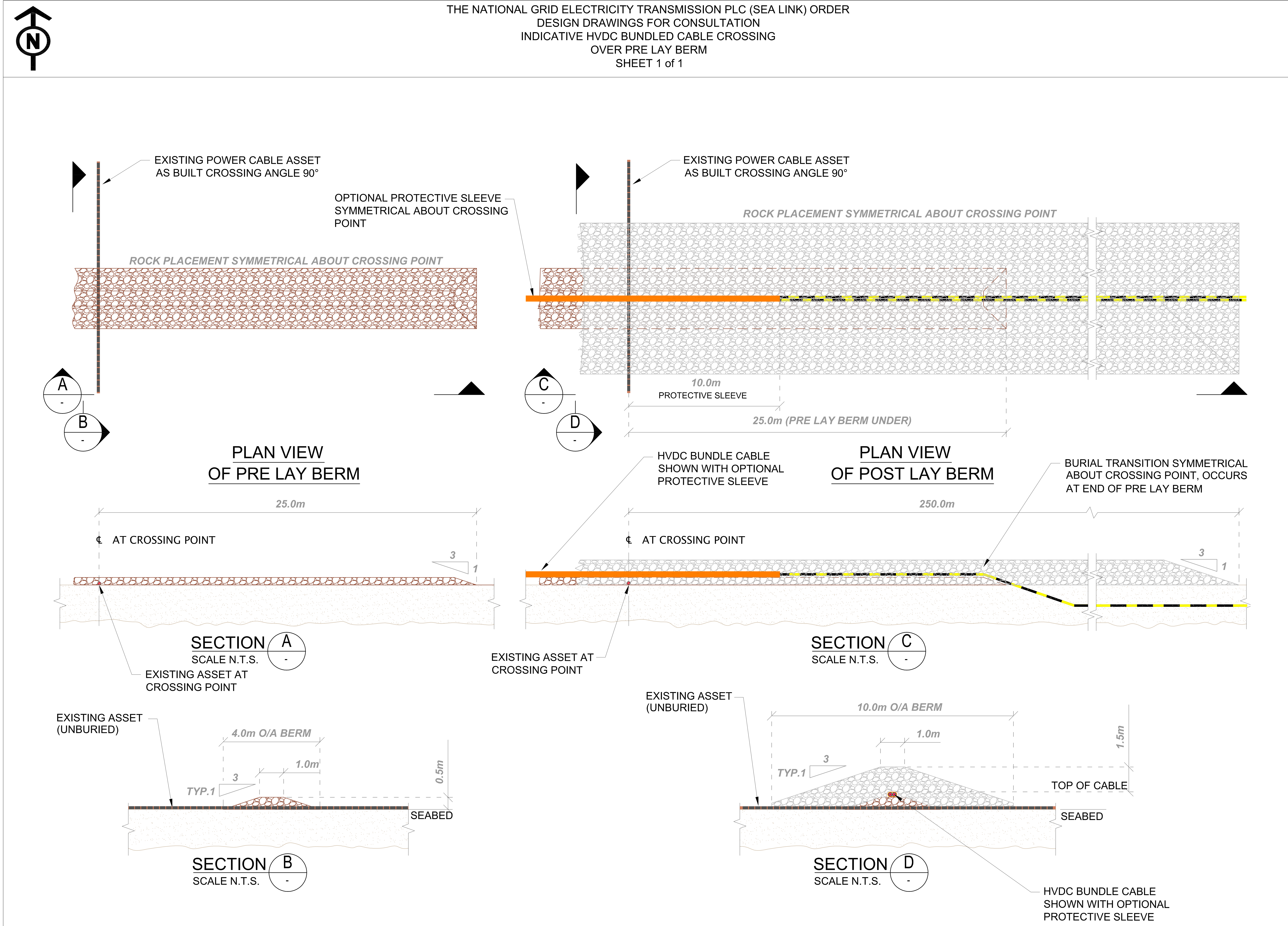
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. Protective sleeves can be added ±10m from crossing point, if required as part of crossing agreement.
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4



Legend

- Post Lay Rock Berm
- Pre Lay Rock Berm
- Existing Asset
- New HVDC Bundle
- Protective Sleeve

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	For Information	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE HVDC BUNDLED CABLE CROSSING
OVER PRE LAY BERM
SHEET 1 of 1

nationalgrid

Application Number

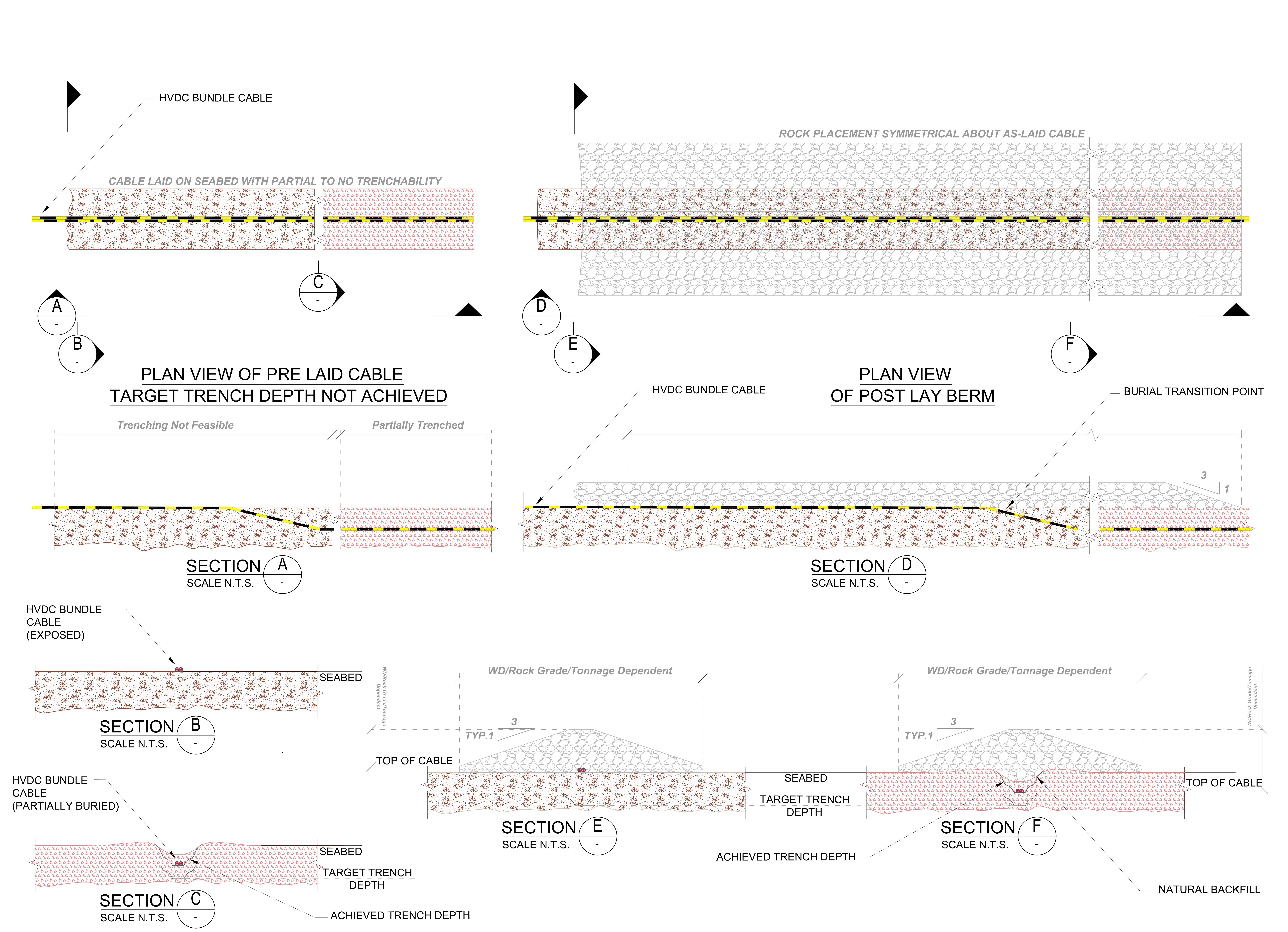
-

National Grid Drawing Reference

S42_M/TDD/SS/1024

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE ROCK BERM SCHEMATICS
PRE LAY AND POST LAY
SHEET 1 of 1



Notes
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1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. Height of berms dependent on water depth, grade of rock & tonnage of rock required for protection.
7. For further explanation of these plans see the Guide to the Plans Document.
8. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend
- Post Lay Rock Berm
- Non-Trenchable Soil
- Semi-Trenchable Soil
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
INDICATIVE ROCK BERM SCHEMATICS
PRE LAY AND POST LAY
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1025

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

ILLUSTRATION OF CABLE PROTECTION SYSTEMS
SHEET 1 of 1

Notes

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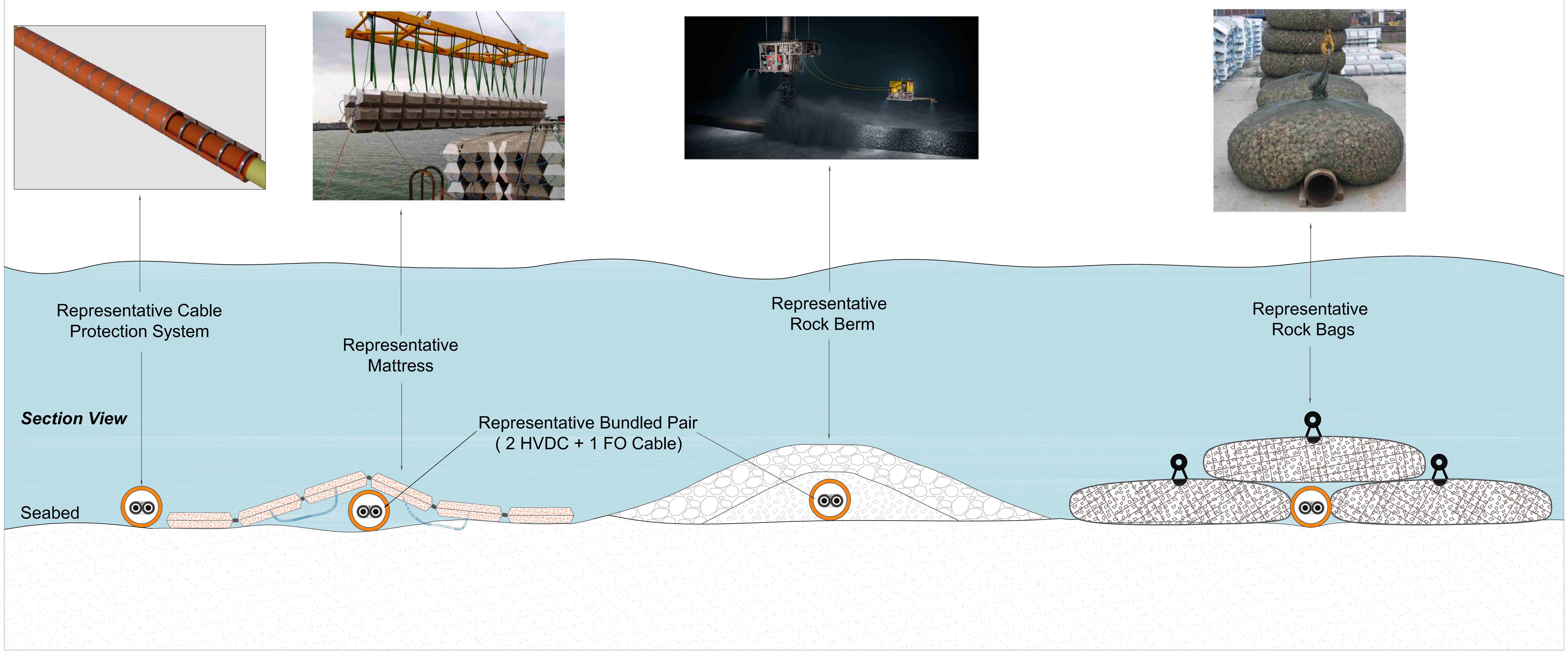
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Representative images of various Cable Protection Methodologies



Legend

- Water
- Seabed Sediment
- Mattress
- Rock Berm
- Rock Bag

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
CABLE PROTECTION SYSTEMS
SHEET 1 of 1

nationalgrid

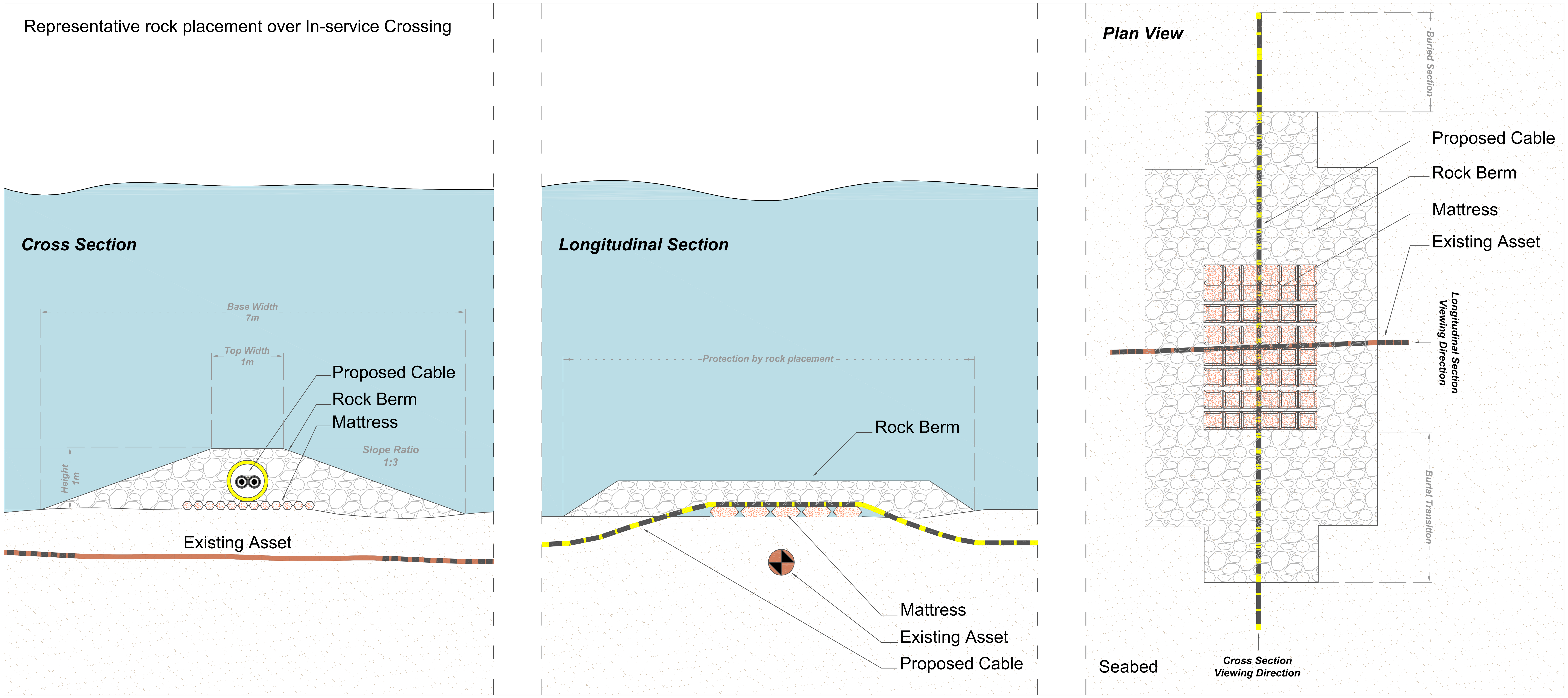
Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1034

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF ROCK PLACEMENT SECTIONS
SHEET 1 of 1



Notes

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4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be agreed during crossing agreement discussions with third parties including burial technique.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Water
- Seabed Sediment
- Mattress (Plan View)
- Mattress (Longitudinal Section)
- Mattress (Cross Section)
- Rock Berm
- Existing Asset
- New HVDC Bundle

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
ROCK PLACEMENT SECTIONS
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1035

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

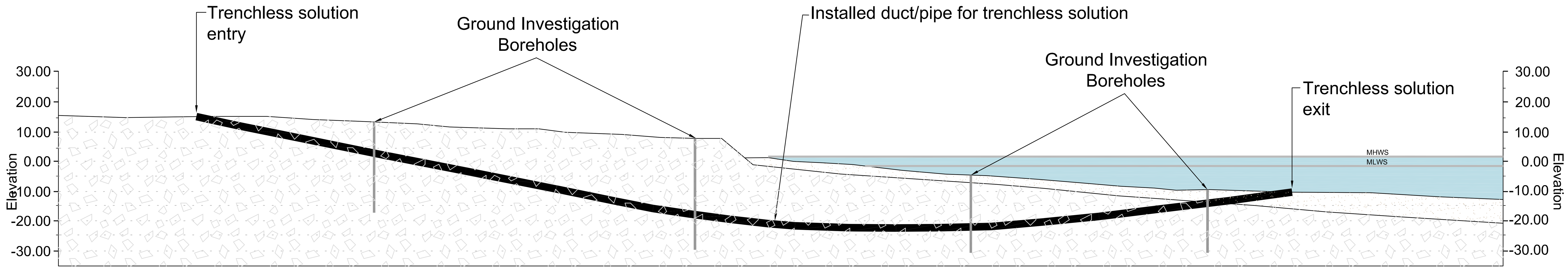
02-05. Landfall Trenchless Installation Technique

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Landfall Trenchless Installation Technique	Illustration of typical HDD landfall	Offshore Schemes	S42_M/TDD/SS/1043

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

ILLUSTRATION OF
TYPICAL HDD LANDFALL
SHEET 1 of 1



Notes

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3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. Typical lengths for example can vary between 800m to 1500m, depending on the local geological ground conditions.
7. HDD = Horizontal Directional Drilling
8. DP = Direct Pipe
9. A trenchless solution may utilise either Horizontal Directional Drilling or Direct Pipe.
10. MHWS = Mean High Water Springs
11. MLWS = Mean Low Water Springs
12. For further explanation of these plans see the Guide to the Plans Document.
13. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4

Legend

- Water
- Seabed Sediment
- Bedrock

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate:N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	24/10/2023	FINAL	AMN	FSS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION
ILLUSTRATION OF
TYPICAL HDD LANDFALL
SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1043

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	A

02-06. Landfall Installation - Aldeburgh For Sea Link Only

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Landfall Installation - Aldeburgh For Sea Link Only	Indicative horizontal direction drill solution for sea link only Aldeburgh	Suffolk Onshore Scheme	S42_M/TDD/SS/1042
	Indicative layout of HDD construction compound for sea link only Aldeburgh	Suffolk Onshore Scheme	S42_M/TDD/SS/1044

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION FOR SEA LINK ONLY ALDEBURGH
SHEET 1 of 1

Notes

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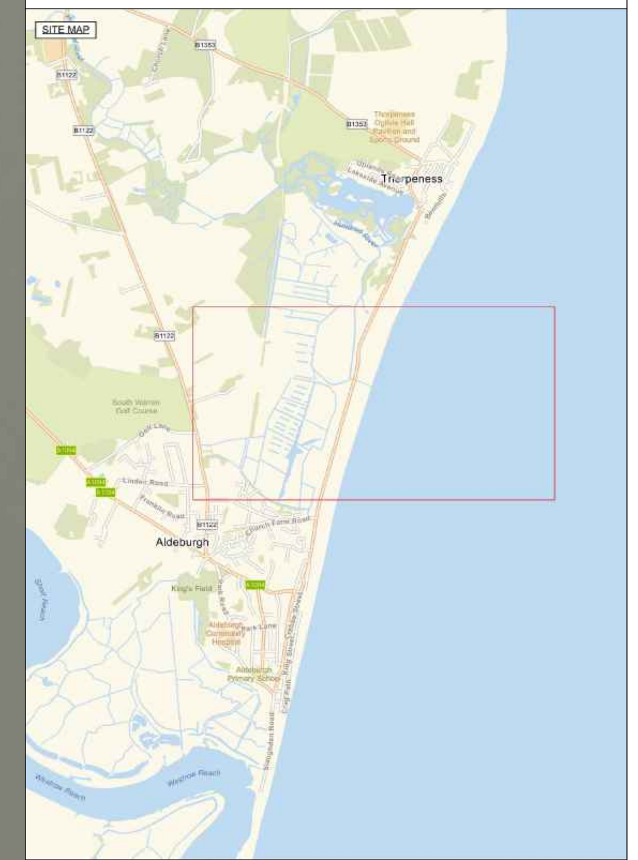
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
10. HDD = Horizontal Directional Drill.



Legend

- Indicative Sea Link HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Draft Order Limit

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION FOR SEA LINK ONLY ALDEBURGH

SHEET 1 of 1

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1042

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

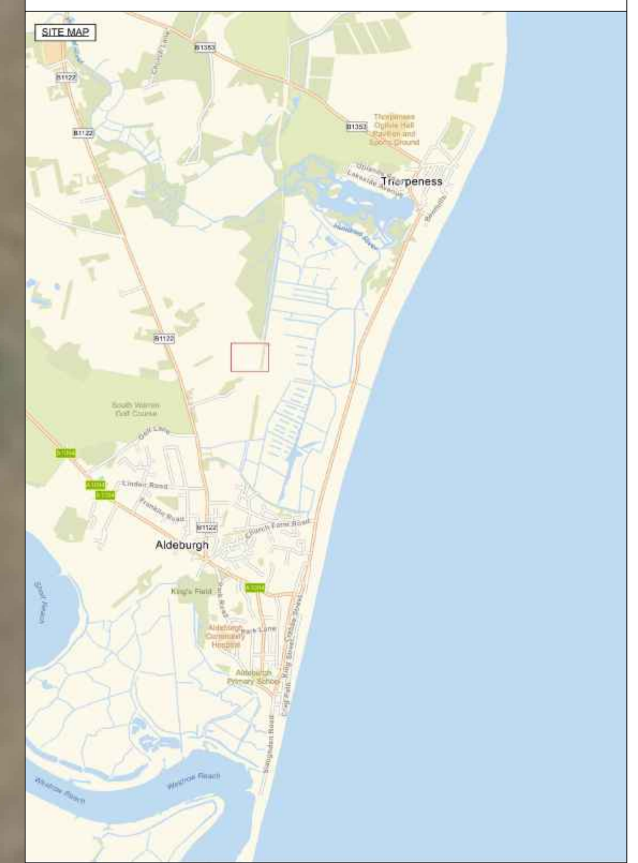
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND FOR SEA LINK ONLY ALDEBURGH
SHEET 1 of 1

Notes

For statutory consultation purposes only

1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
9. For indicative HDD alignments see Drawing No. S42_M/TDD/SS/1042
10. HDD = Horizontal Directional Drill.



Legend

- Indicative Sea Link HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Draft Order Limit

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate: N/A

A	25/08/2023	FINAL	TR	FS	KG
Issue	Date	Remarks	Drawn	Checked	Approved

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND FOR SEA LINK ONLY ALDEBURGH

SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1044

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

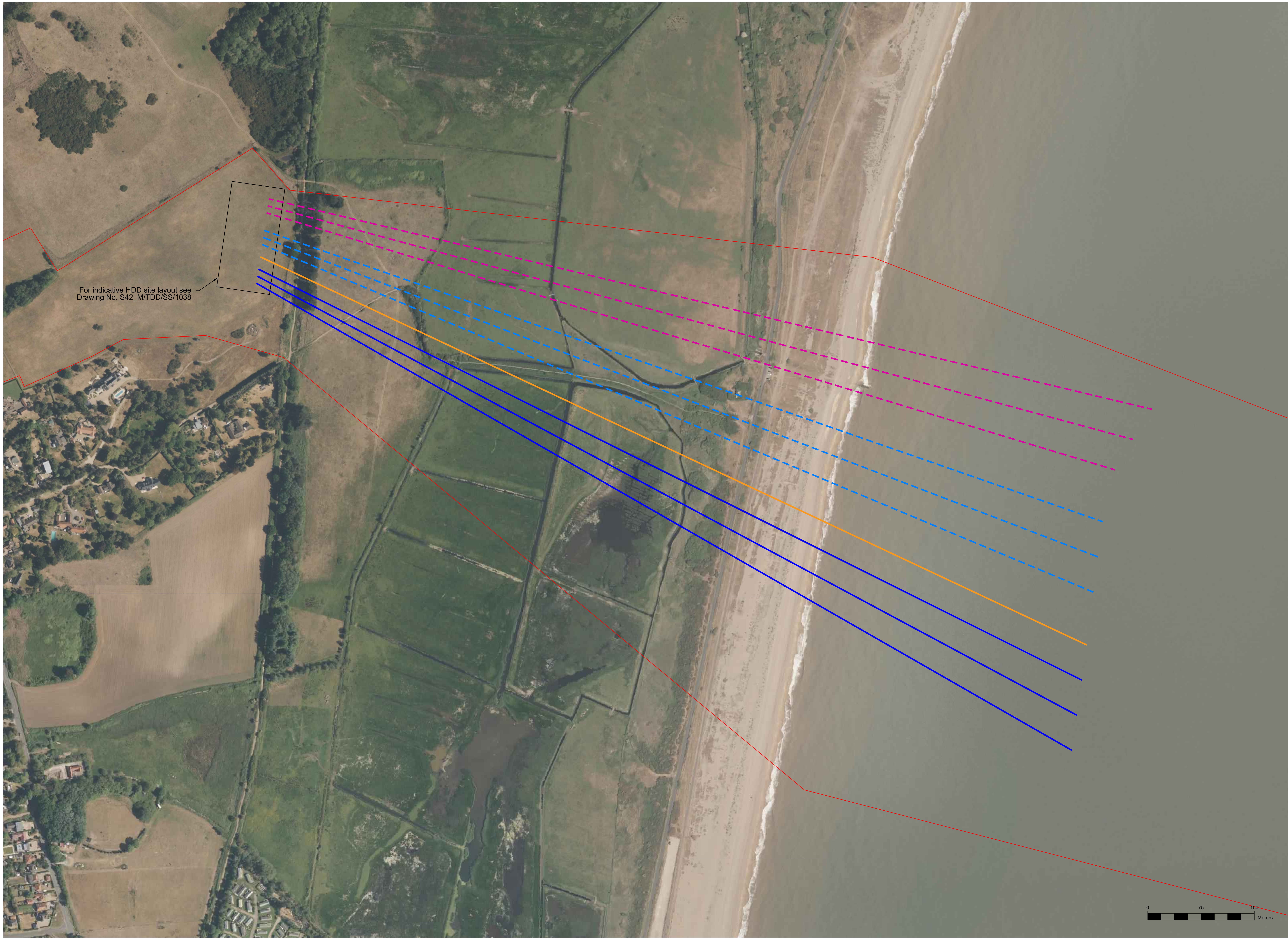
02-07. Landfall Installation - Aldeburgh For Sea Link Plus Ducts for up to two further projects

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Landfall Installation - Aldeburgh For Sea Link Plus Ducts for up to two further projects	Indicative horizontal directional drill solution for sea link plus ducts for up to two further projects Aldeburgh	Suffolk Onshore Scheme	S42_M/TDD/SS/1041
	Indicative layout of HDD construction compound for sea link plus ducts for up to two further projects Aldeburgh	Suffolk Onshore Scheme	S42_M/TDD/SS/1038

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS ALDEBURGH
SHEET 1 of 1



Notes

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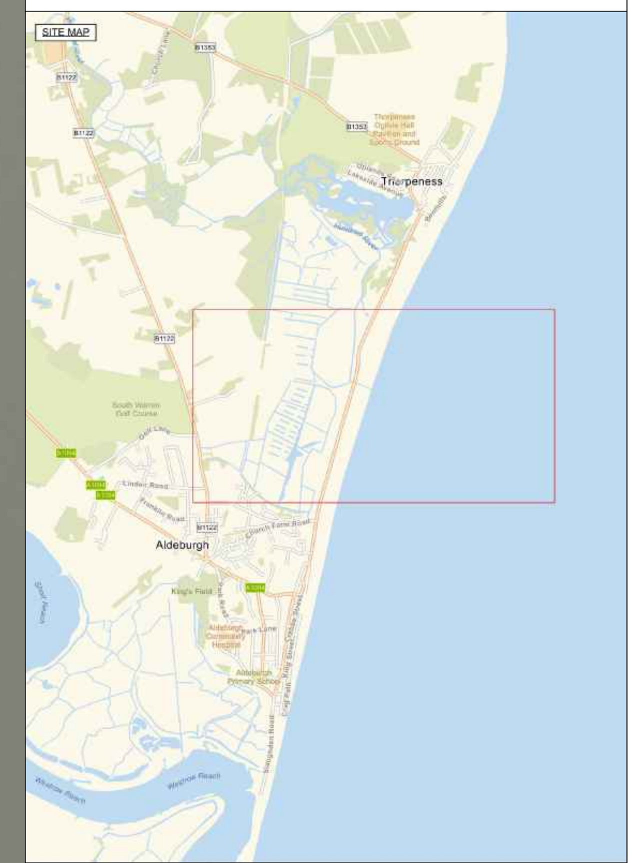
1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
10. HDD = Horizontal Directional Drill.



Legend

- Indicative Sea Link HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Indicative Additional Co-Location Ducts
- Indicative Additional Co-Location Ducts
- Draft Order Limit

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS ALDEBURGH

SHEET 1 of 1

nationalgrid

Application Number
-

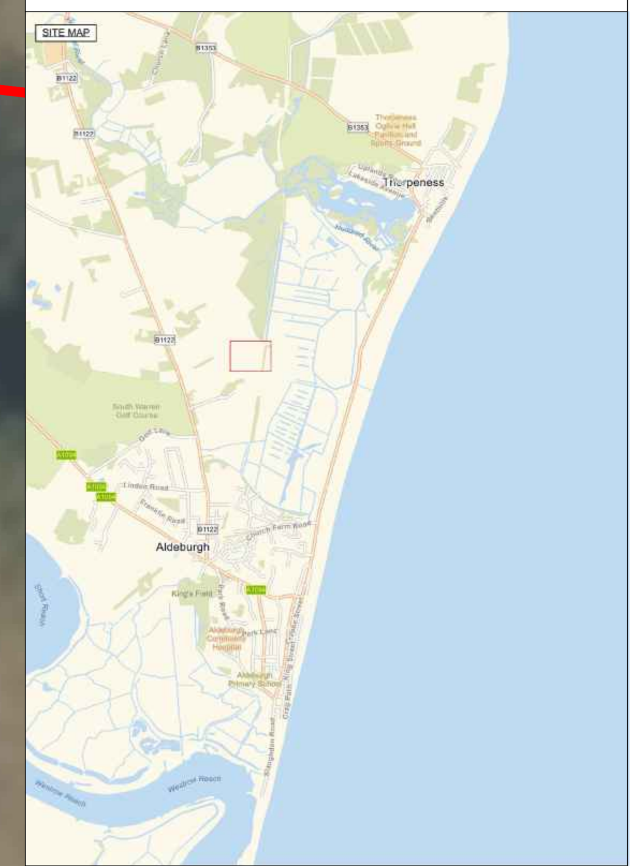
National Grid Drawing Reference
S42_M/TDD/SS/1041

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS ALDEBURGH
SHEET 1 of 1

Notes
For statutory consultation purposes only
1. Do not scale from this drawing.
2. All dimensions are in metres/millimetres unless otherwise stated.
3. This drawing is to be read in conjunction with all relevant documents and drawings.
4. No unauthorised disclosure, storage or copying.
5. Detailed design, including final dimensions, to be decided at a later date.
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
9. For indicative HDD alignments see Drawing No. S42_M/TDD/SS/1041
10. HDD = Horizontal Directional Drill.



Legend

- Indicative Sea Link HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Indicative Additional Co-Location Ducts
- Indicative Additional Co-Location Ducts
- Draft Order Limit

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND FOR SEA LINK PLUS DUCTS FOR UP TO TWO FURTHER PROJECTS ALDEBURGH

SHEET 1 of 1

nationalgrid

Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1038

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

02-08. Landfall Installation - Pegwell Bay

Drawing Category Name	Plan Title	Scheme	Drawing Numbers
Landfall Installation - Pegwell Bay	Indicative horizontal directional drill solution Pegwell bay	Kent Onshore Scheme	S42_M/TDD/SS/1039
	Indicative layout of HDD construction compound Pegwell bay	Kent Onshore Scheme	S42_M/TDD/SS/1037
	Indicative direct pipe solution Pegwell bay	Kent Onshore Scheme	S42_M/TDD/SS/1040

To assist with understanding these drawings please see the **Guide to Interacting with the Consultation Plans and Drawings**

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION PEGWELL BAY
SHEET 1 of 1

Notes

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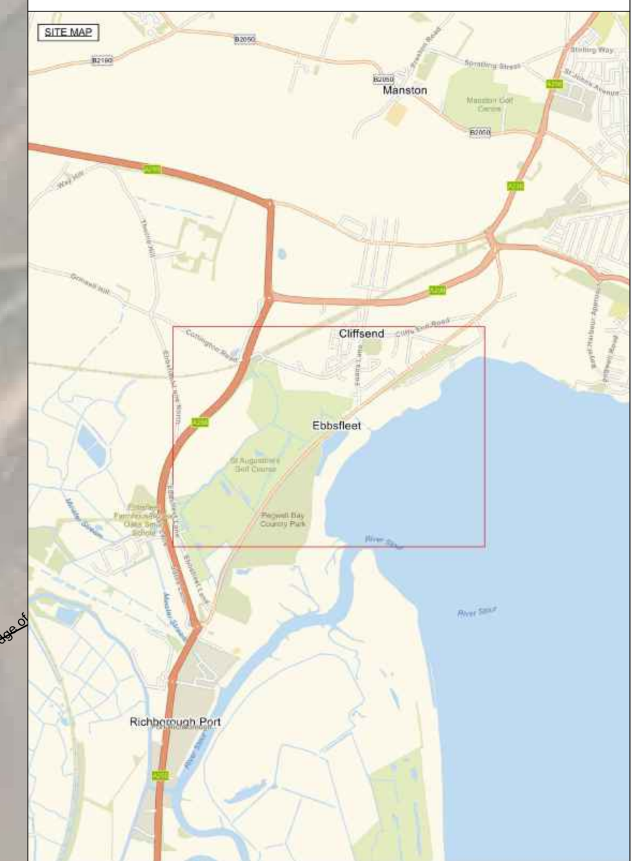
6. For further explanation of these plans see the Guide to the Plans Document.
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
9. HDD = Horizontal Directional Drill.



Legend

- Indicative HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Indicative HDD duct stringing for pushed installation
- Draft Order Limit
- Historic Landfill

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE HORIZONTAL DIRECTIONAL DRILL SOLUTION PEGWELL BAY

SHEET 1 of 1

nationalgrid

Application Number

-

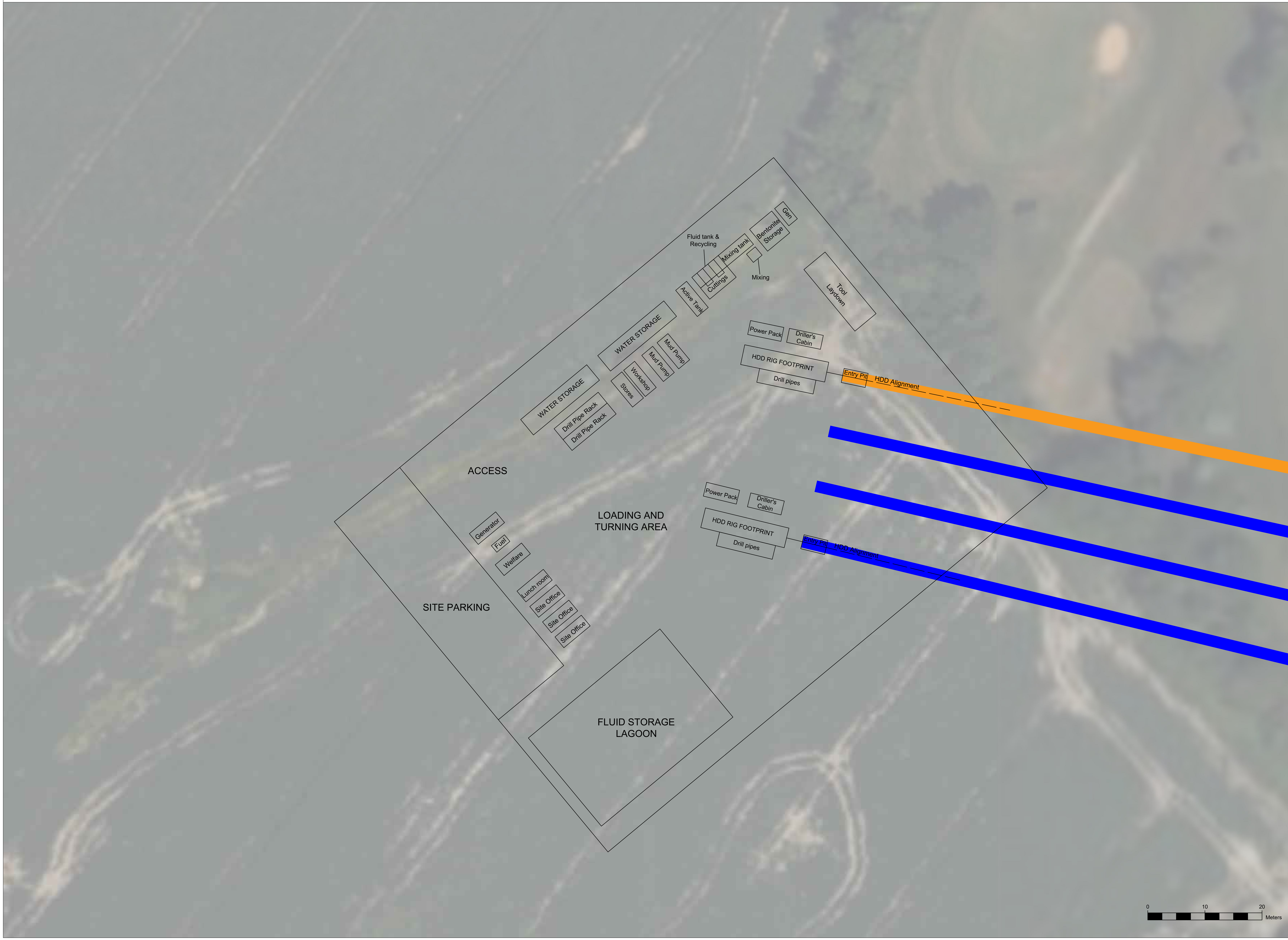
National Grid Drawing Reference

S42_M/TDD/SS/1039

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND PEGWELL BAY
SHEET 1 of 1



Notes

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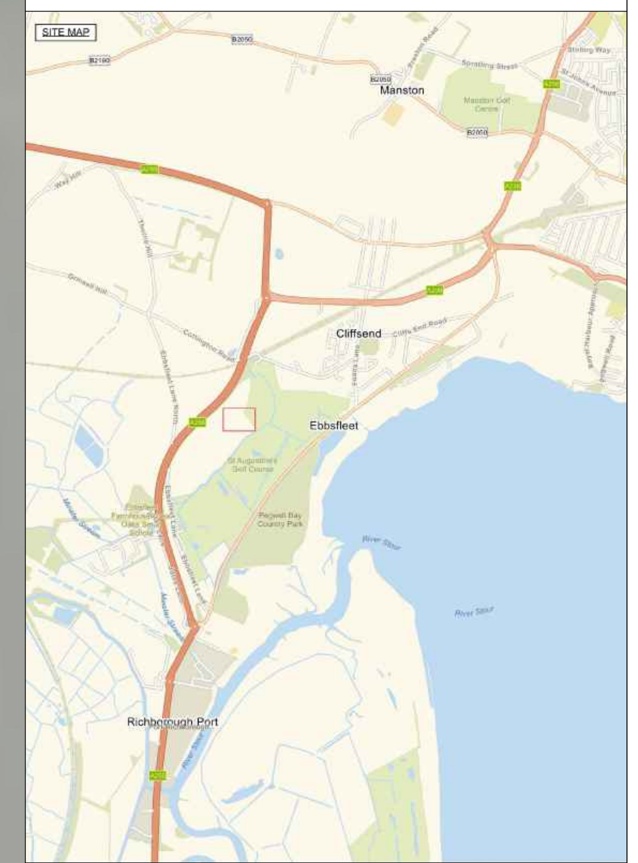
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.
9. For indicative HDD alignments see Drawing No. S42_M/TDD/SS/1039
10. For General Arrangement Plan see Drawing No. S42_K/IGA/PS/2003
11. HDD = Horizontal Directional Drill.



Legend

- Indicative HDD Alignment
- Indicative Reserve HDD Alignment - duct only
- Draft Order Limit

Sheet X Centroid Coordinate: N/A Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title
THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE LAYOUT OF HDD CONSTRUCTION COMPOUND PEGWELL BAY

SHEET 1 of 1

nationalgrid

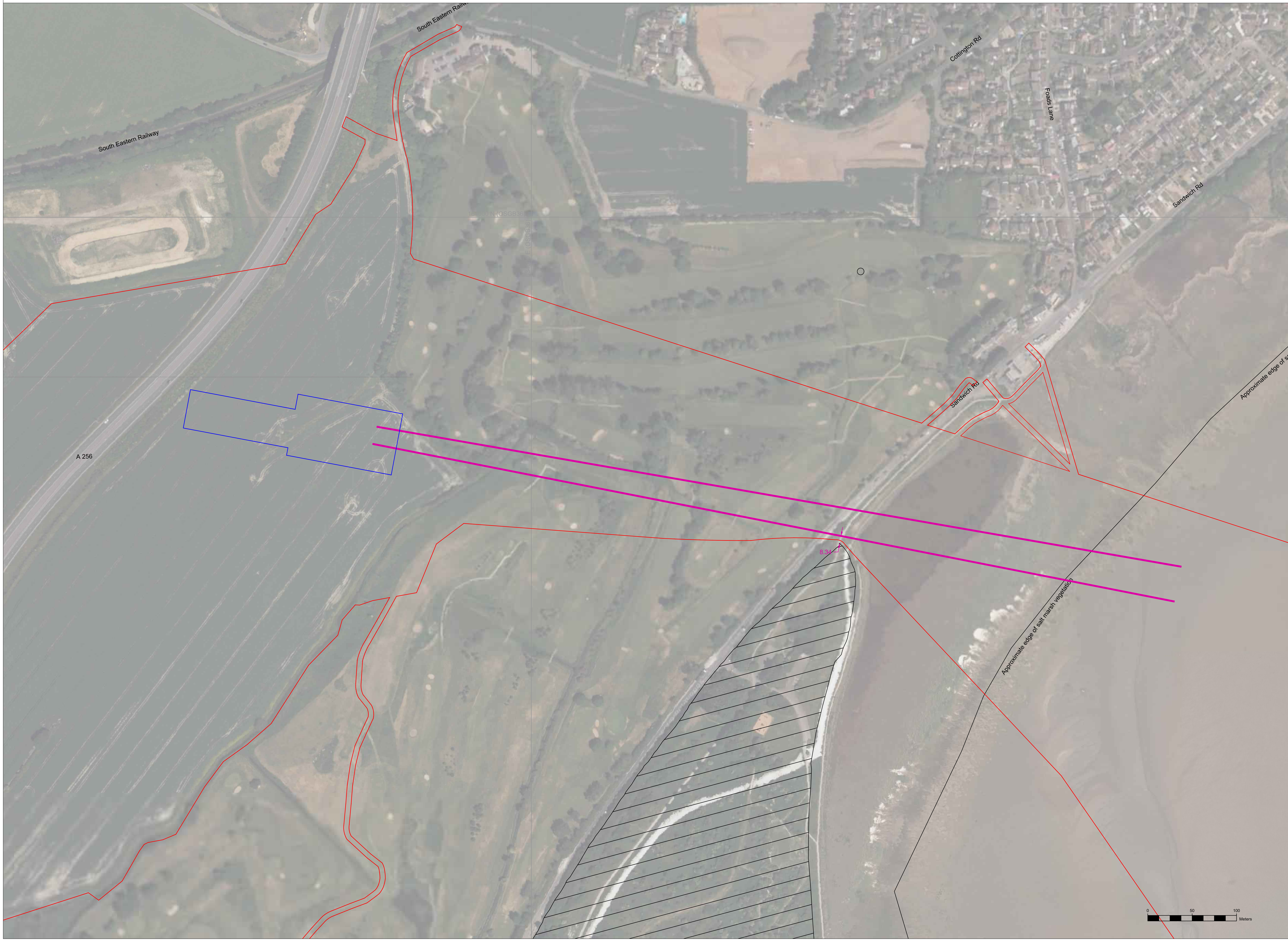
Application Number
-

National Grid Drawing Reference
S42_M/TDD/SS/1037

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER
DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE DIRECT PIPE SOLUTION PEGWELL BAY
SHEET 1 of 1



Notes

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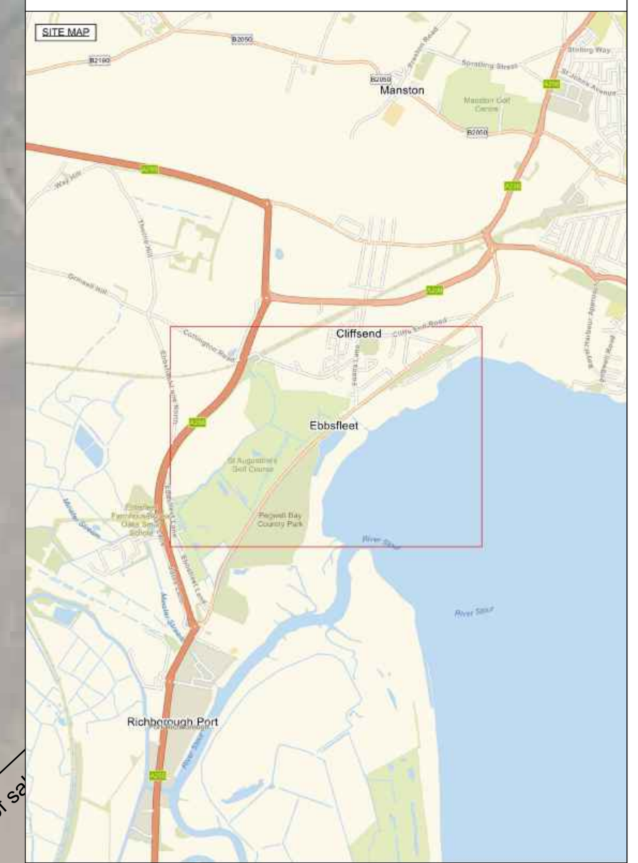
7. For further information on construction please refer to the construction section of the Preliminary Environmental Impact Report, Volume 1, Part 1, Chapter 4.
8. Background Bing Maps aerial photography from Spatial Manager application, © 2019 Microsoft.



Legend

- Indicative Direct Pipe Alignment
- Indicative Direct Pipe Working Area
- Draft Order Limit
- Historic Landfill

Sheet X Centroid Coordinate: N/A   Sheet Y Centroid Coordinate: N/A

Issue	Date	Remarks	Drawn	Checked	Approved
A	25/08/2023	FINAL	TR	FS	KG

Title: THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (SEA LINK) ORDER

DESIGN DRAWINGS FOR CONSULTATION

INDICATIVE DIRECT PIPE SOLUTION PEGWELL BAY

SHEET 1 of 1

nationalgrid

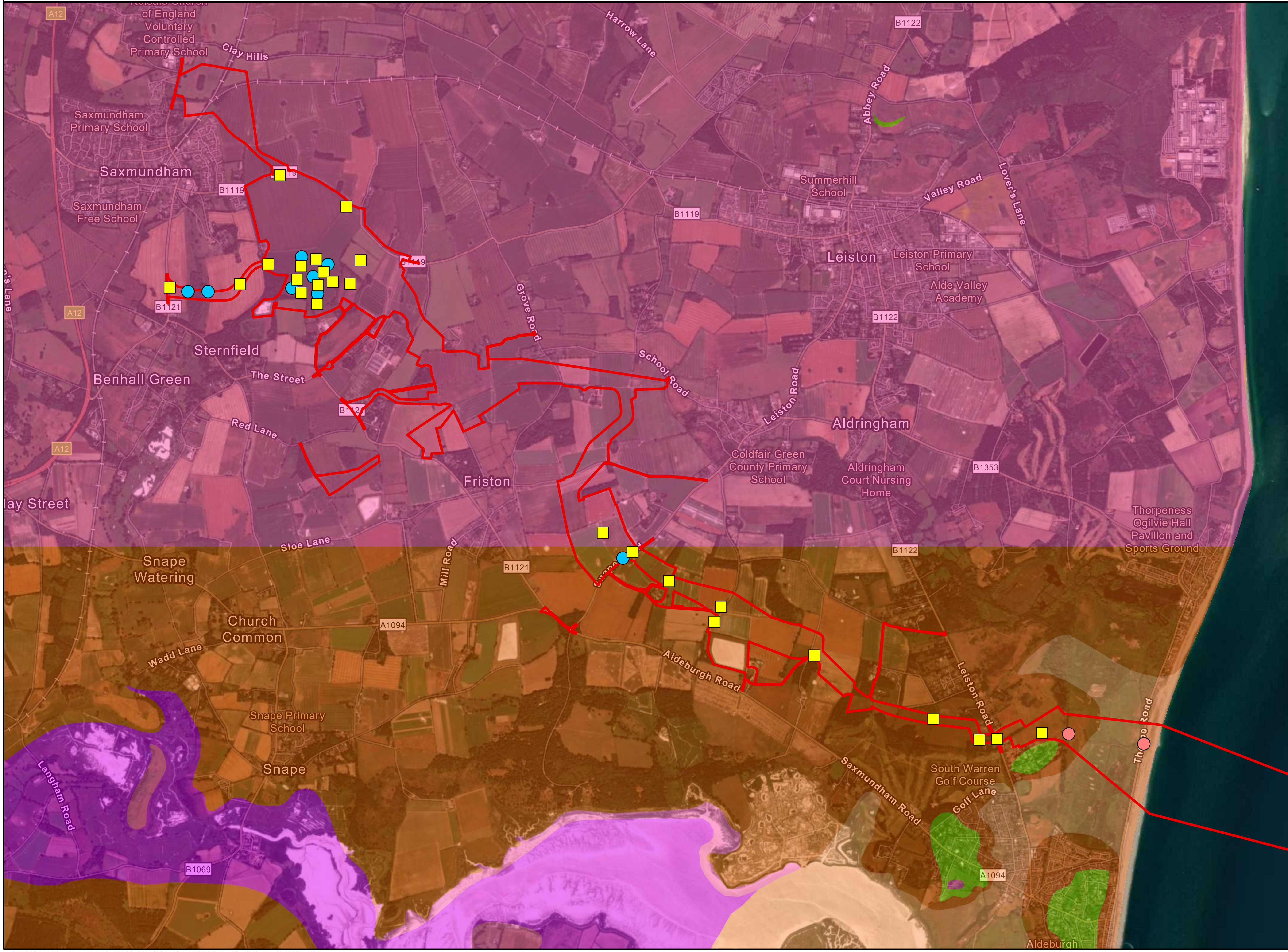
Application Number: -

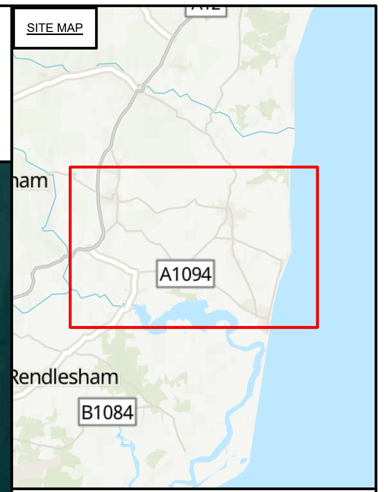
National Grid Drawing Reference: S42_M/TDD/SS/1040

Scale	Sheet Size	Sheet	Issue
NTS	A1	SHEET 1 OF 1	01

Exploratory hole location plans

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
BEDROCK GEOLOGY OVERVIEW
SHEET 1 OF 1
SUFFOLK





Legend

Draft Order Limits

Exploratory hole locations (as built)

- Borehole
- Red Penguin Borehole
- Trial Pit

Bedrock Geology

- Chillesford Church Sand Member - Sand
- Chillesford Clay Member - Clay, silty
- Coralline Crag Formation - Calcarenite
- Crag Group - Sand

Notes

1. This drawing is scaled at paper size A3, therefore any prints taken at smaller sizes will affect accuracy of the measurement units and should not be scaled against
2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 642608.13 Sheet Y Centroid Coordinate: 260598.86

0 295 590 1,180 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	11/04/24	For Information	JF	PF	LG

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
BEDROCK GEOLOGY OVERVIEW
SHEET 1 OF 1
SUFFOLK

nationalgrid

Application Number

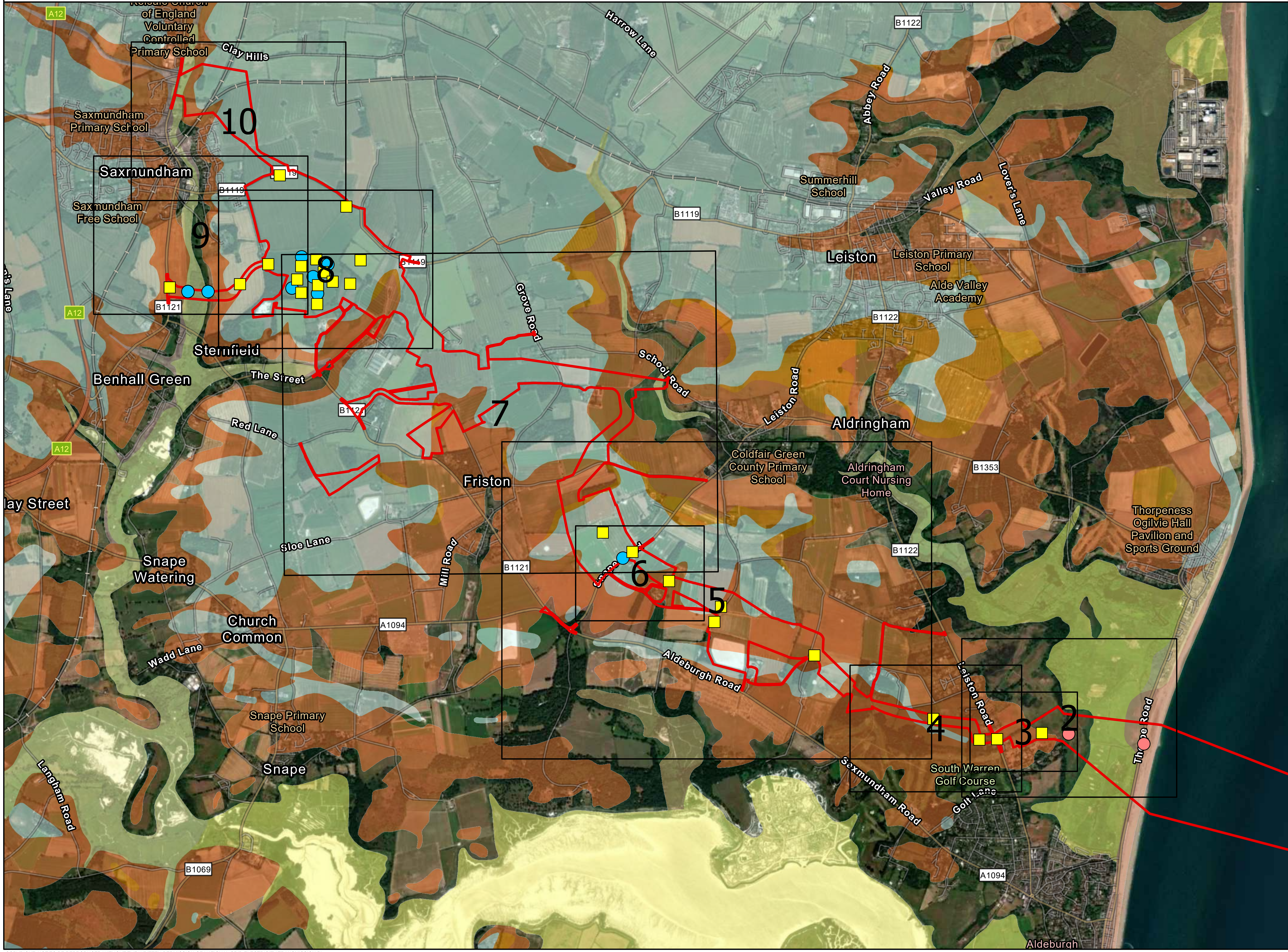
EN020026

National Grid Drawing Reference

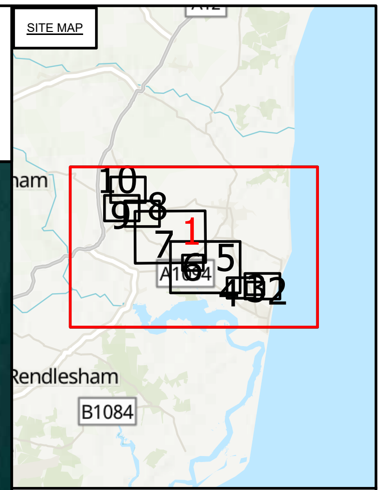
SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:30,000	A3	SHEET 1 OF 1	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
SUPERFICIAL GEOLOGY OVERVIEW
SHEET 1 OF 10
SUFFOLK



SITE MAP



Legend

Draft Order Limits

Exploratory hole locations (as built)

- Borehole
- Red Penguin Borehole
- Trial Pit

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel

Notes

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2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 642608.13 Sheet Y Centroid Coordinate: 260598.86

0 295 590 1,180 Metres

01	02/04/24	For Information	JF	PF	LG
Issue	Date	Remarks	Drawn	Checked	Approved

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
SUPERFICIAL GEOLOGY OVERVIEW
SHEET 1 OF 10
SUFFOLK

nationalgrid

Application Number

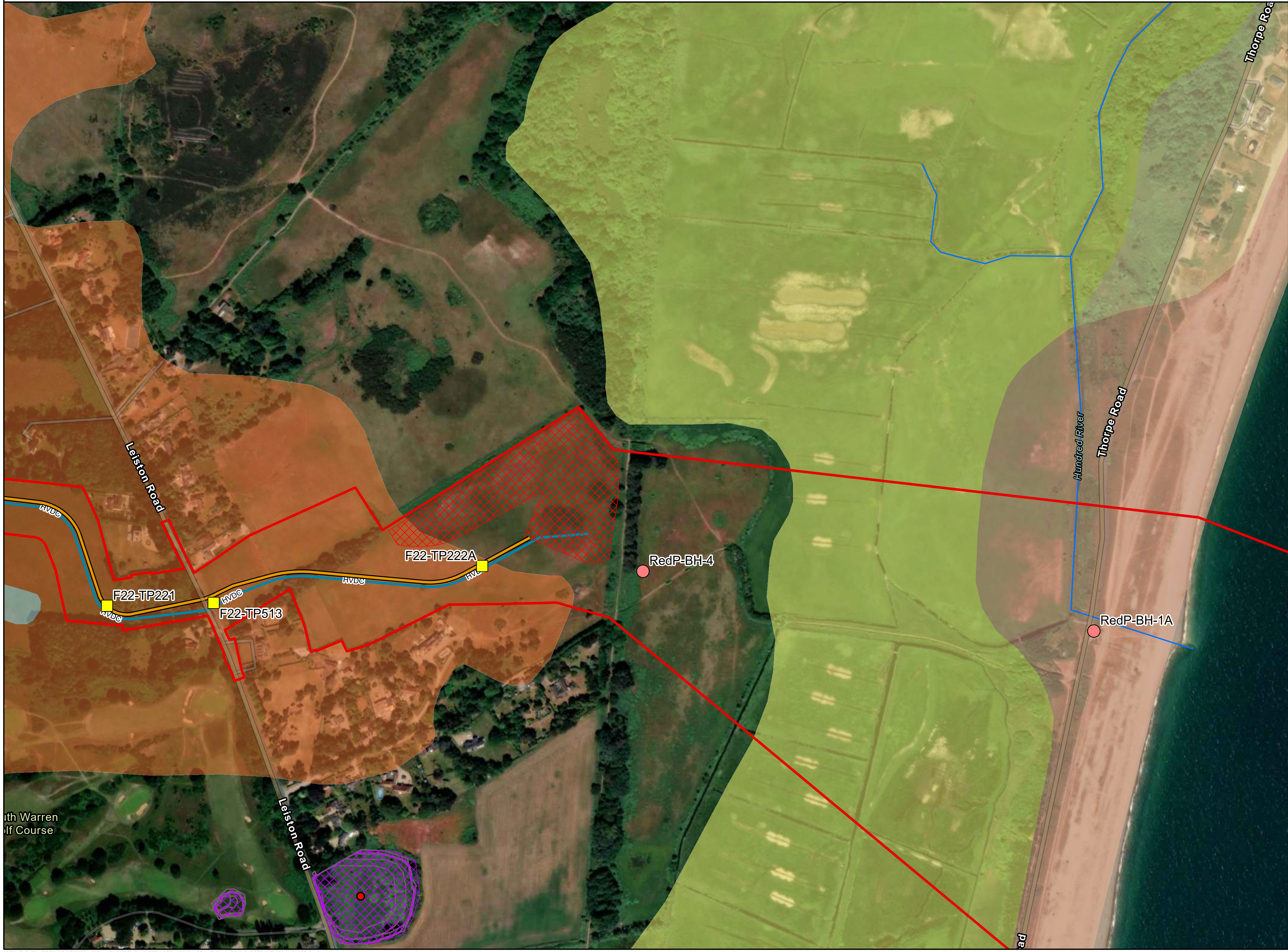
EN020026

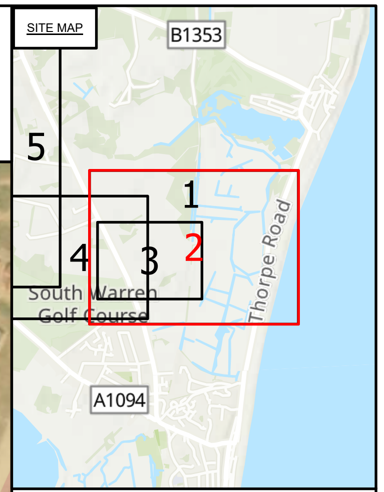
National Grid Drawing Reference

SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:30,000	A3	SHEET 1 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 2 OF 10
SUFFOLK





Legend

- Draft Order Limits
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed construction compound
- Proposed access route

Exploratory hole locations (as built)

- Red Penguin Borehole
- Trial Pit

Key historical features

- Brit pit
- Historical industrial land uses
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel
- Watercourse

Notes

1. This drawing is scaled at paper size A3, therefore any prints taken at smaller sizes will affect accuracy of the measurement units and should not be scaled against
2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 646183.13 Sheet Y Centroid Coordinate: 258552.89

0 50 100 200 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

Title

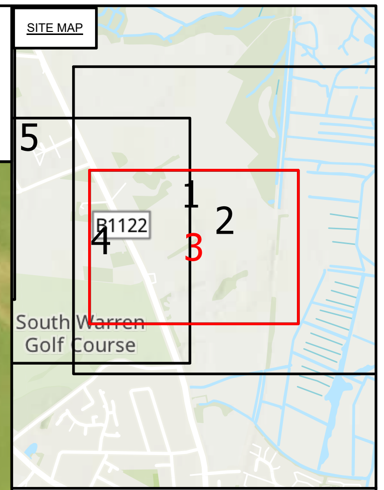
NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 2 OF 10
SUFFOLK

Application Number: EN020026

National Grid Drawing Reference: SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:5,000	A3	SHEET 2 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 3 OF 10
SUFFOLK



Legend

- Draft Order Limits
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed construction compound
- Proposed access route

Exploratory hole locations (as built)

- Red Penguin Borehole
- Trial Pit

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel

Notes

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2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 645798.63 Sheet Y Centroid Coordinate: 258436.63

0 25 50 100 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 3 OF 10
SUFFOLK

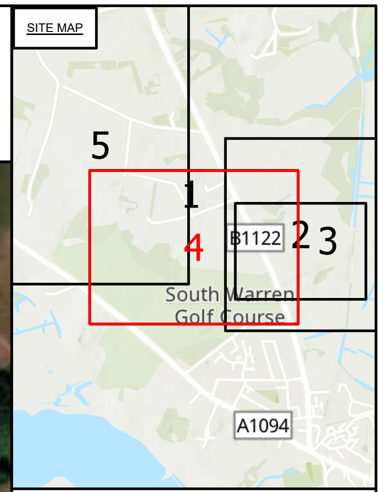
nationalgrid

Application Number: EN020026

National Grid Drawing Reference: SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:2,500	A3	SHEET 3 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 4 OF 10
SUFFOLK



Legend

- Draft Order Limits
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed access route

Exploratory hole locations (as built)

- Trial Pit

Key historical features

- Brit pit
- Historical industrial land uses
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel

Notes

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2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 645056.06 Sheet Y Centroid Coordinate: 258464.48

0 40 80 160 Metres

01	02/04/24	For Information	JF	PF	LG
Issue	Date	Remarks	Drawn	Checked	Approved

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 4 OF 10
SUFFOLK

nationalgrid

Application Number

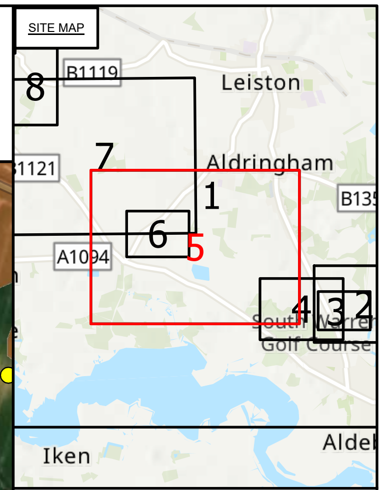
EN020026

National Grid Drawing Reference

SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:4,000	A3	SHEET 4 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 5 OF 10
SUFFOLK



Legend

- Draft Order Limits
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed construction compound
- Proposed access route

Exploratory hole locations (as built)

- Borehole
- Trial Pit
- BGS borehole
- SPR borehole

Key historical features

- Brit pit
- Historical industrial land uses
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel
- Watercourse

Notes

1. This drawing is scaled at paper size A3, therefore any prints taken at smaller sizes will affect accuracy of the measurement units and should not be scaled against
2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 643204.5 Sheet Y Centroid Coordinate: 259546.2

0 100 200 400 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

Title

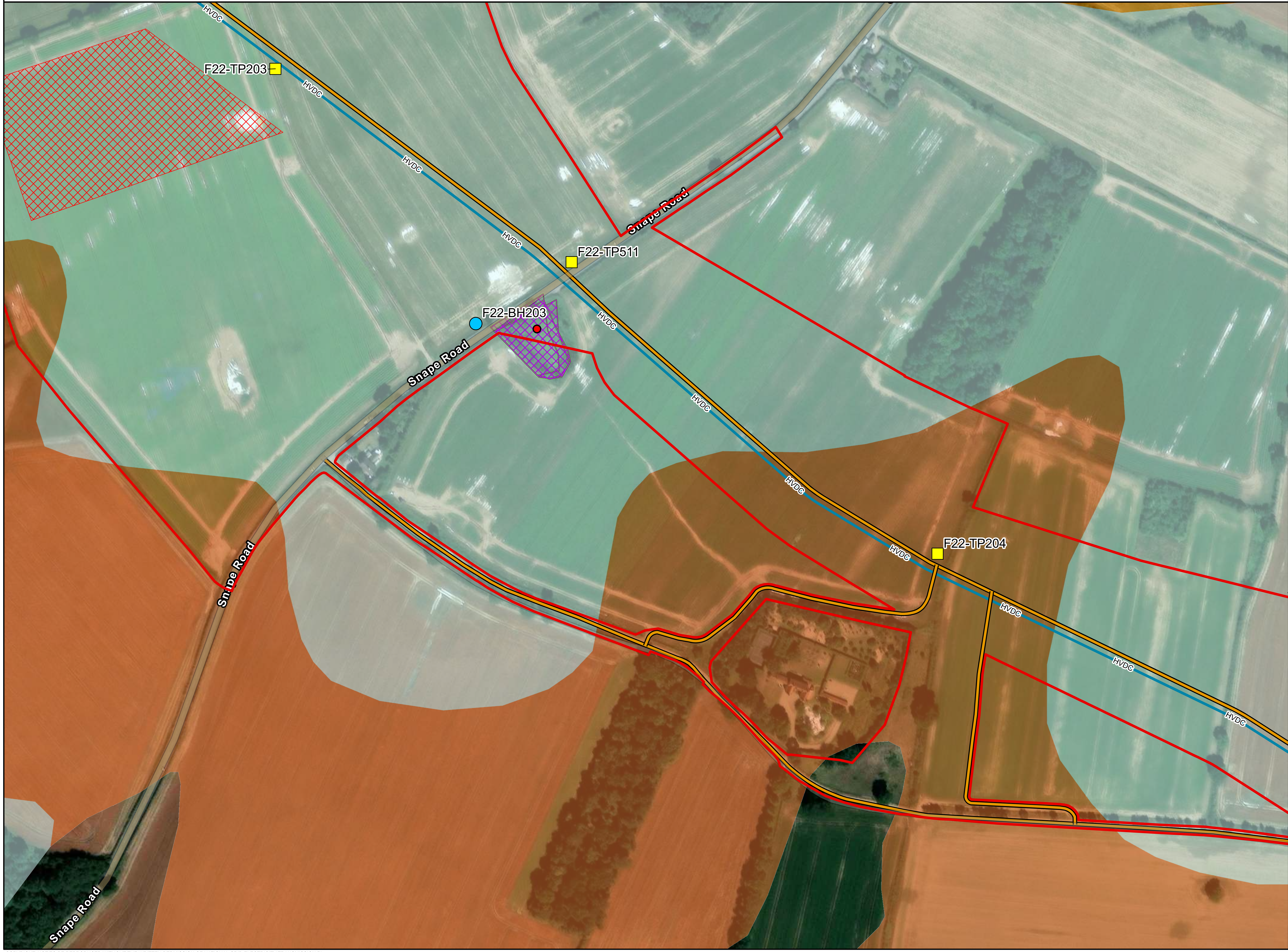
NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 5 OF 10
SUFFOLK

Application Number
EN020026

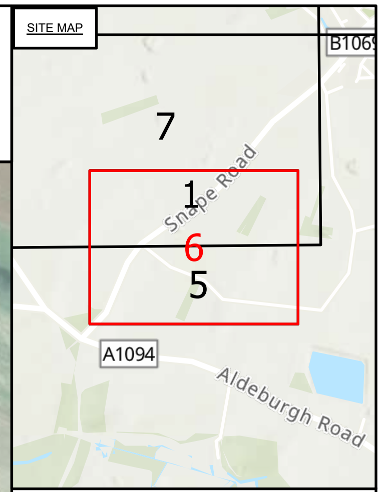
National Grid Drawing Reference
SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:10,000	A3	SHEET 5 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 6 OF 10
SUFFOLK



SITE MAP



Legend

- Draft Order Limits
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed construction compound
- Proposed access route

Exploratory hole locations (as built)

- Borehole
- Trial Pit

Key historical features

- Brit pit
- Historical industrial land uses
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel

Notes

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2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 642555.31 Sheet Y Centroid Coordinate: 259774.2

0 30 60 120 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 6 OF 10
SUFFOLK

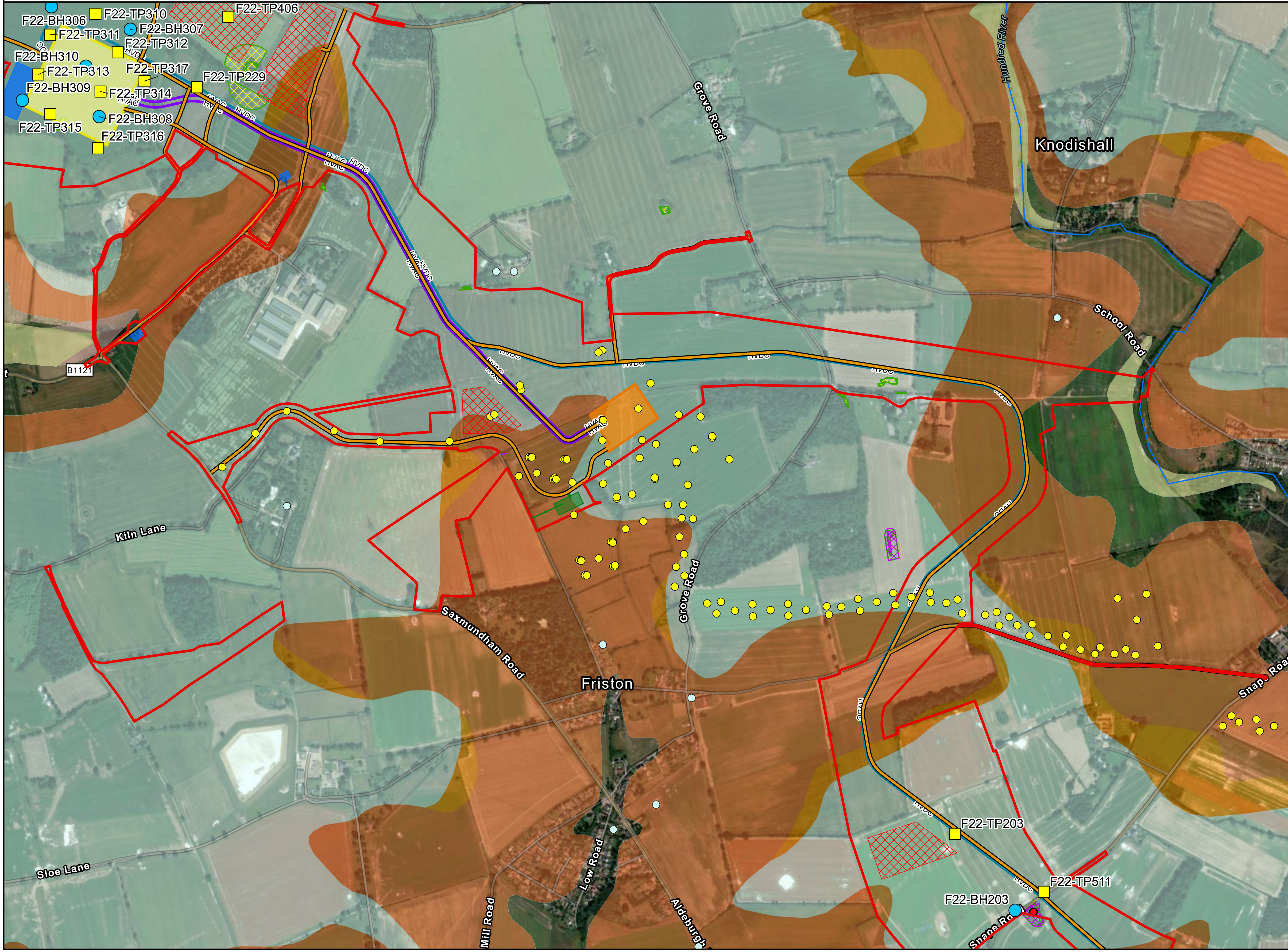
nationalgrid

Application Number
EN020026

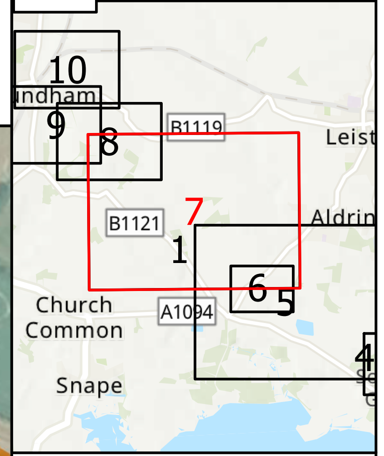
National Grid Drawing Reference
SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:3,000	A3	SHEET 6 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 7 OF 10
SUFFOLK



SITE MAP



Legend

- Draft Order Limits
- Proposed substation
- Proposed converter station
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed High Voltage Alternating Current (HVAC) cable alignment
- Proposed construction compound
- Proposed permanent infiltration pond
- Proposed permanent infiltration outfall pipe
- Proposed permanent attenuation pond
- Proposed permanent attenuation outfall pipe
- Proposed access route

Exploratory hole locations (as built)

- Borehole
- Trial Pit
- BGS borehole
- SPR borehole

Key historical features

- Brit pit
- Historical industrial land uses
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel
- Watercourse

Notes

1. This drawing is scaled at paper size A3, therefore any prints taken at smaller sizes will affect accuracy of the measurement units and should not be scaled against
2. Features are not to scale

Coordinate System: British National Grid
Sheet X Centroid Coordinate: 642263.31 Sheet Y Centroid Coordinate: 260013.06

0 100 200 400 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

Title

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY
AND HISTORICAL AND CURRENT LAND USES
SHEET 7 OF 10
SUFFOLK

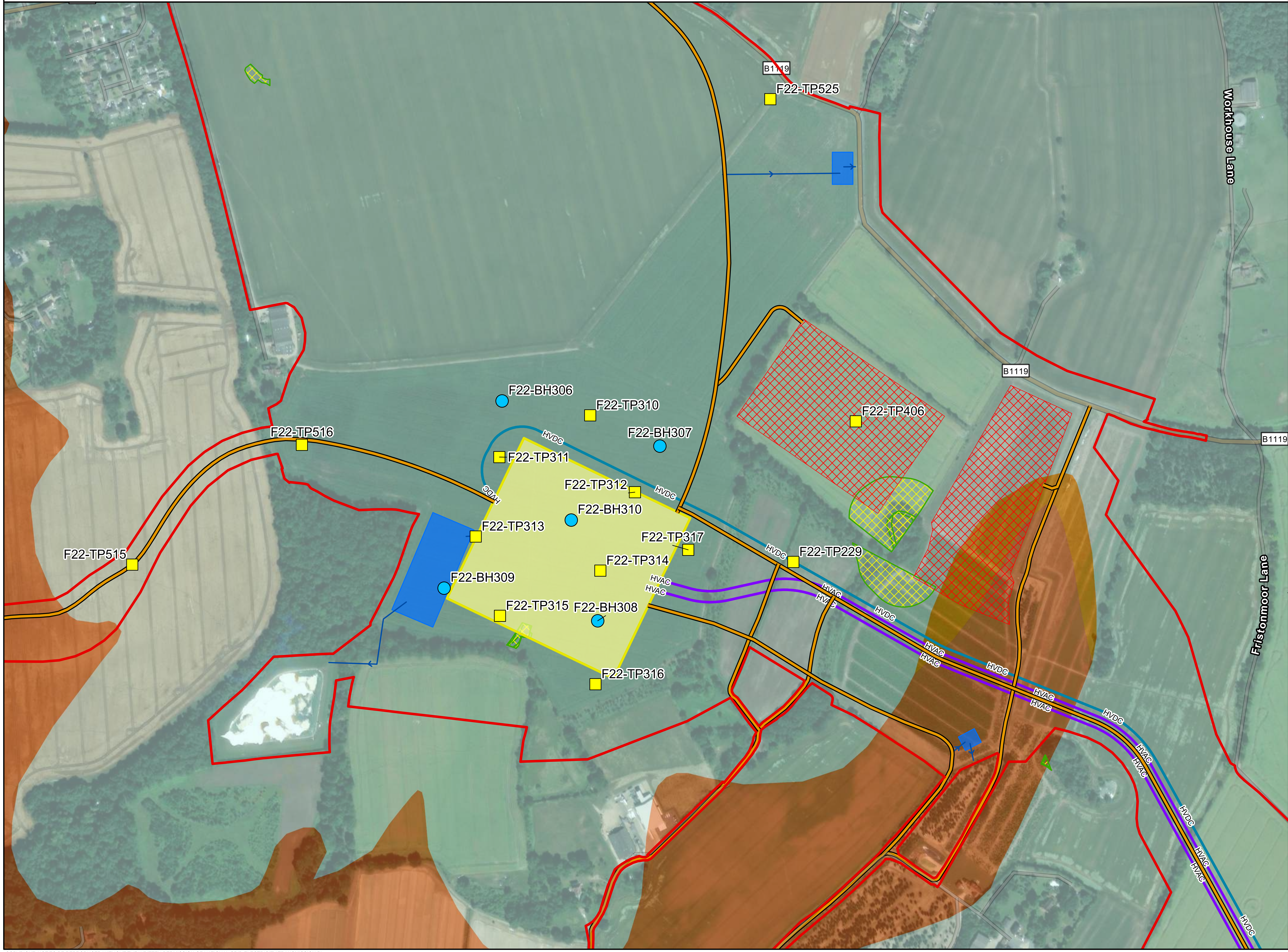
nationalgrid

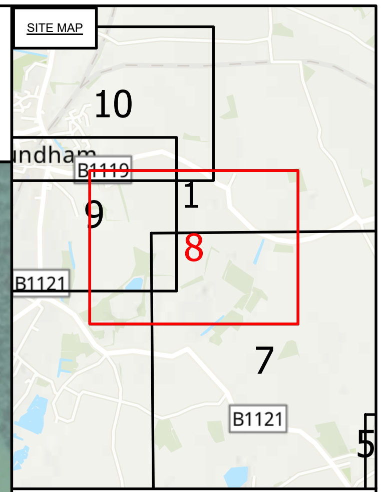
Application Number
EN020026

National Grid Drawing Reference
SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:10,000	A3	SHEET 7 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 8 OF 10
SUFFOLK





Legend

- Draft Order Limits
- Proposed converter station
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed High Voltage Alternating Current (HVAC) cable alignment
- Proposed construction compound
- Proposed permanent attenuation pond
- Proposed permanent attenuation outfall pipe
- Proposed access route

Exploratory hole locations (as built)

- Borehole
- Trial Pit
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel

Notes

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2. Features are not to scale

Coordinate System: British National Grid
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0 50 100 200 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

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NATIONAL GRID (SEA LINK) ORDER
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AND HISTORICAL AND CURRENT LAND USES
SHEET 8 OF 10
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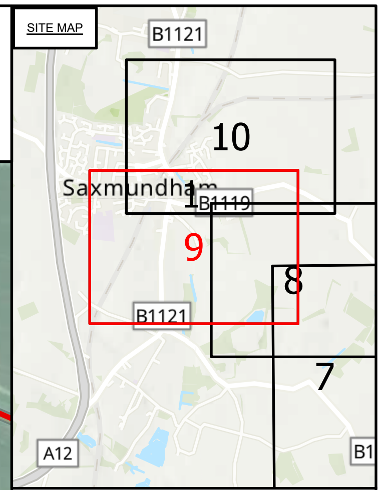
nationalgrid

Application Number: EN020026

National Grid Drawing Reference: SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:5,000	A3	SHEET 8 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
INCLUDING SUPERFICIAL GEOLOGY AND HISTORICAL AND CURRENT LAND USES
SHEET 9 OF 10
SUFFOLK



Legend

- Draft Order Limits
- Proposed converter station
- Proposed High Voltage Direct Current (HVDC) cable alignment
- Proposed permanent attenuation pond
- Proposed permanent attenuation outfall pipe
- Proposed access route

Exploratory hole locations (as built)

- Borehole
- Trial Pit
- BGS borehole
- Surface ground workings

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel
- Watercourse

Notes

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2. Features are not to scale

Coordinate System: British National Grid
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0 50 100 200 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

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NATIONAL GRID (SEA LINK) ORDER
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SHEET 9 OF 10
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nationalgrid

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National Grid Drawing Reference
SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:5,000	A3	SHEET 9 OF 10	01

NATIONAL GRID (SEA LINK) ORDER
GROUND INVESTIGATION -
EXPLORATORY HOLE LOCATION PLAN
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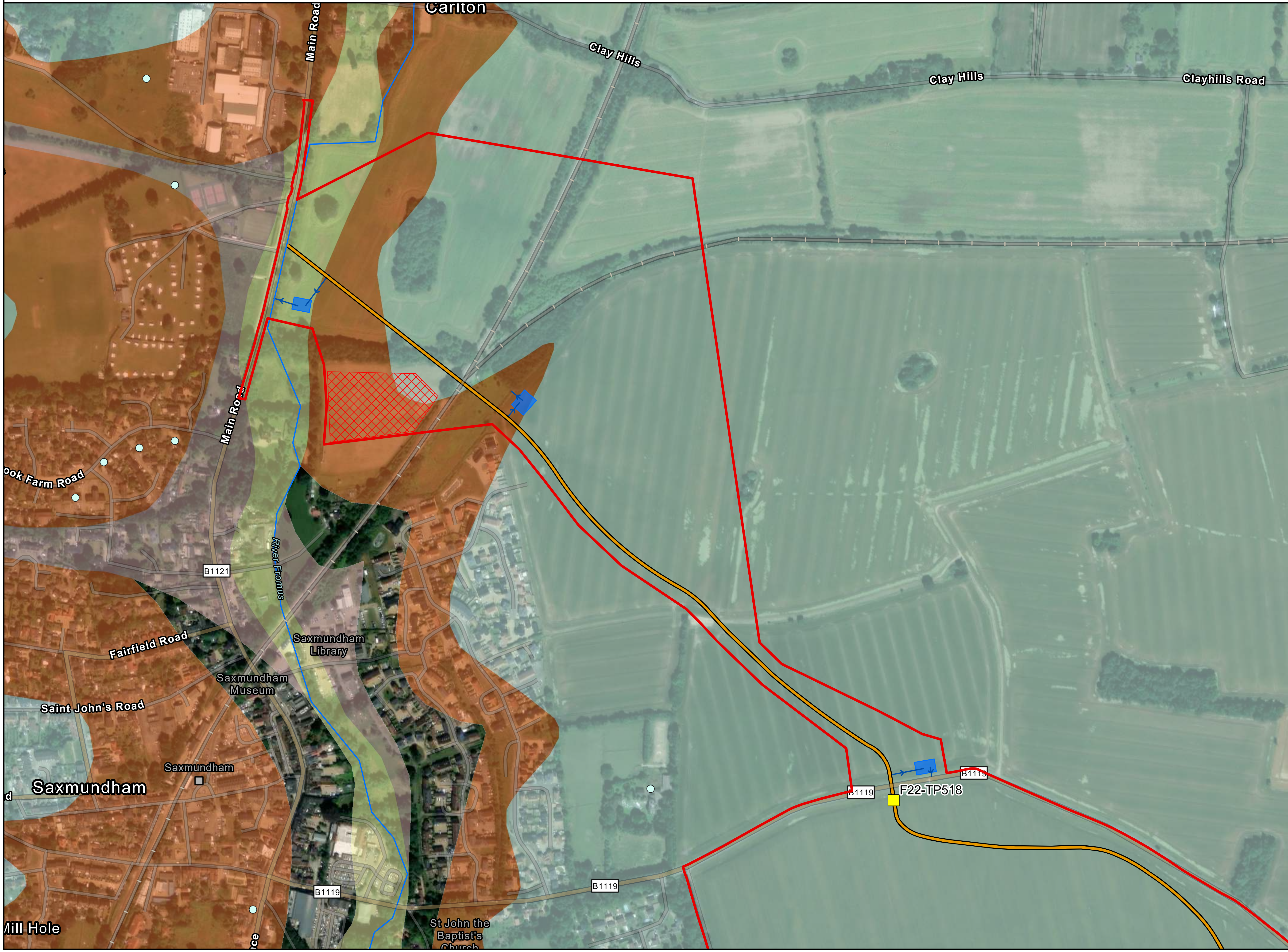
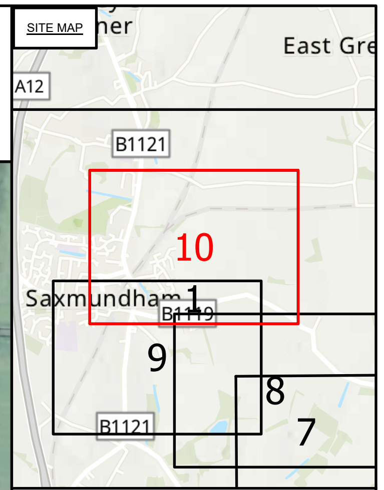
SHEET 10 OF 10
SUFFOLK



SITE MAP



Legend

- Draft Order Limits
- Proposed construction compound
- Proposed permanent attenuation pond
- Proposed permanent attenuation outfall pipe
- Proposed access route

Exploratory hole locations (as built)

- Trial Pit
- BGS borehole

Superficial Geology

- Alluvium - Clay, silt, sand and gravel
- Lowestoft Formation - Clay and silt
- Lowestoft Formation - Diamicton
- Lowestoft Formation - Sand and gravel
- Marine Beach Deposits - Sand and gravel
- Tidal Flat Deposits - Clay and Silt
- Head - Clay, silt, sand and gravel
- Watercourse

Notes

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0 50 100 200 Metres

Issue	Date	Remarks	Drawn	Checked	Approved
01	02/04/24	For Information	JF	PF	LG

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SHEET 10 OF 10
SUFFOLK

nationalgrid

Application Number: EN020026

National Grid Drawing Reference: SEAL-MMD-SEAL-ENG-DWG-0685

Scale	Sheet Size	Sheet	Issue
1:5,000	A3	SHEET 10 OF 10	01

Figure A.1: Source Protection Zones

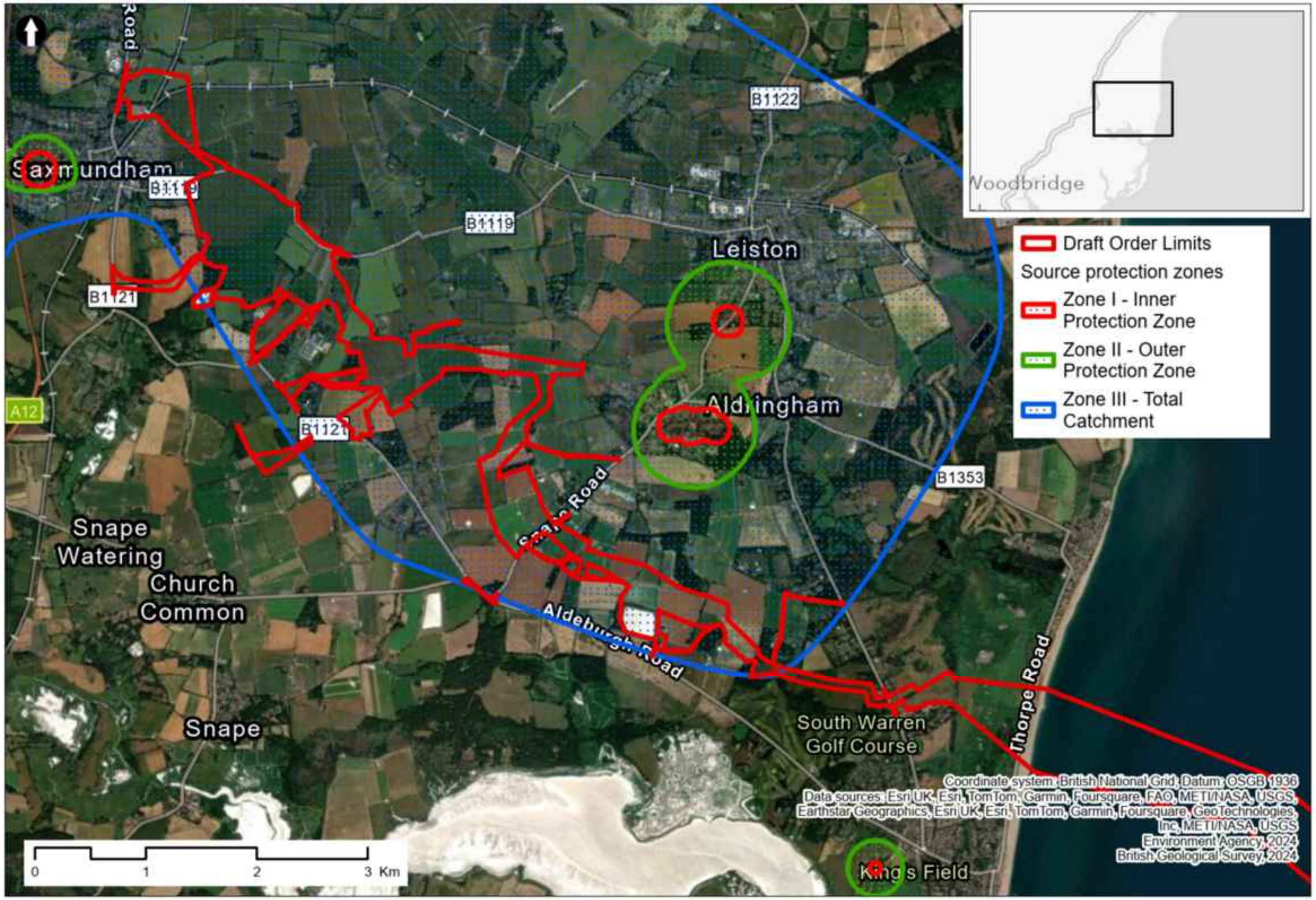


Figure A.2: British Geological Survey – Soluble Rock risk

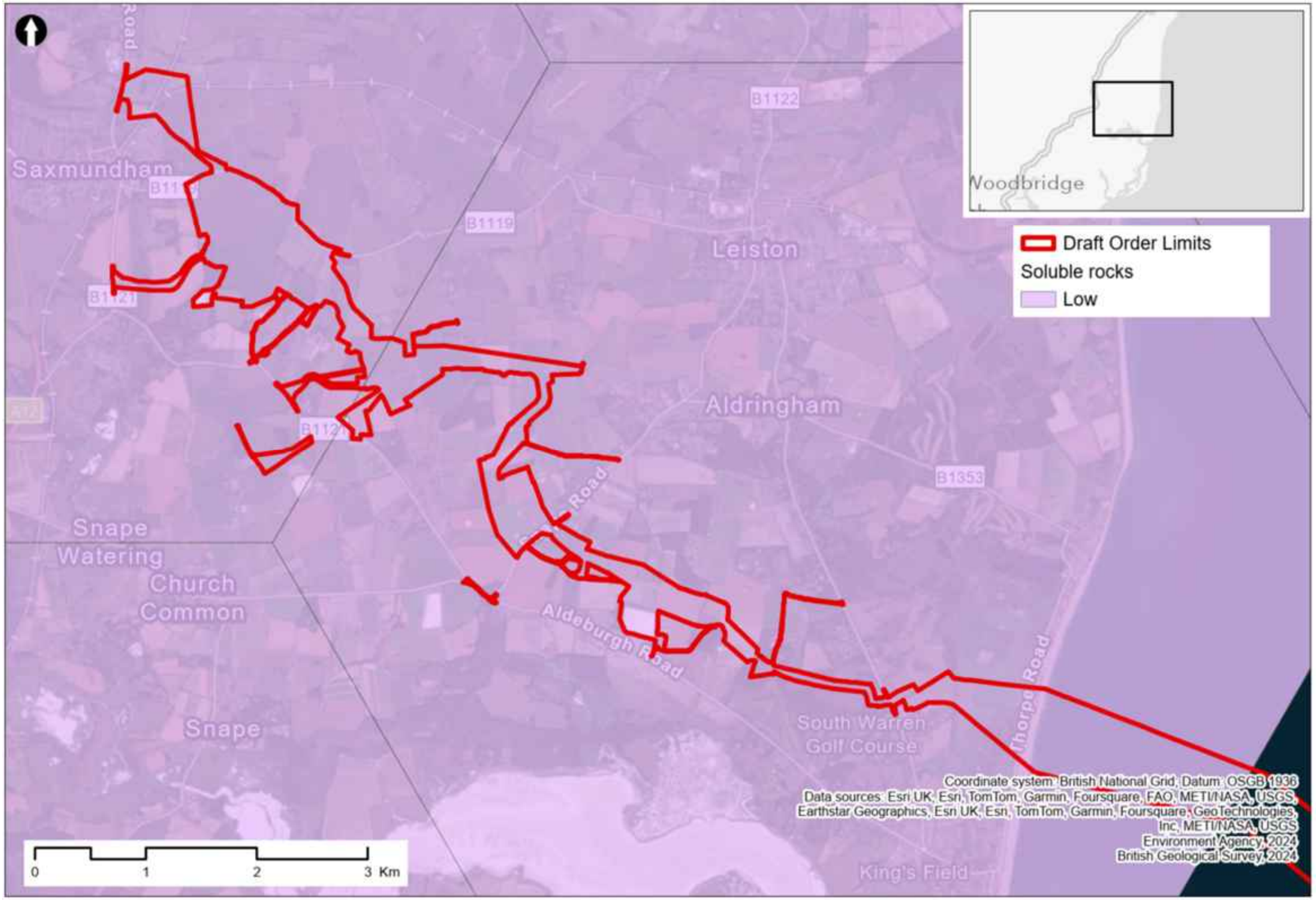


Figure A.3: British Geological Survey – Shrink swell risk

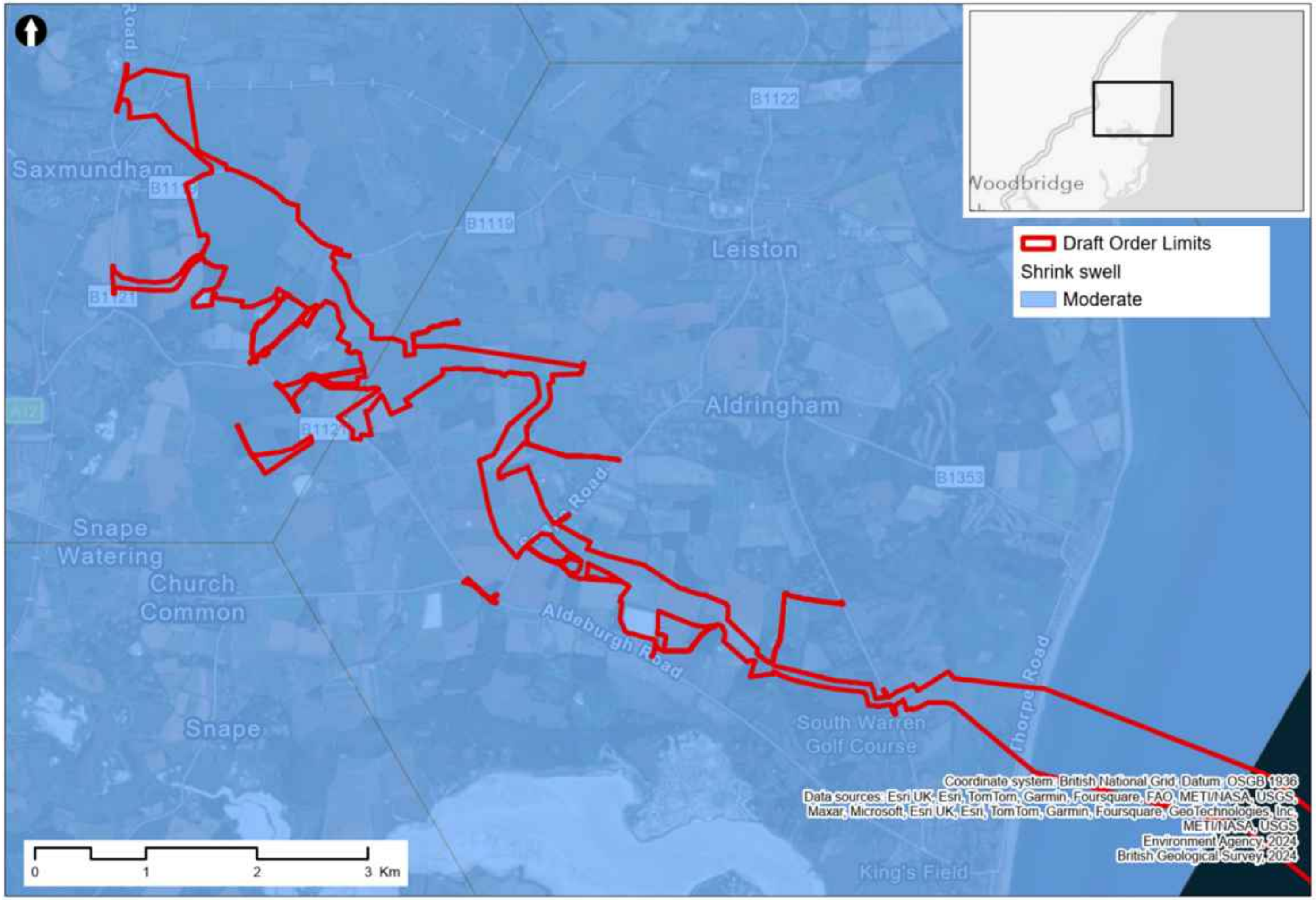


Figure A.4: British Geological Survey – Running sand risk

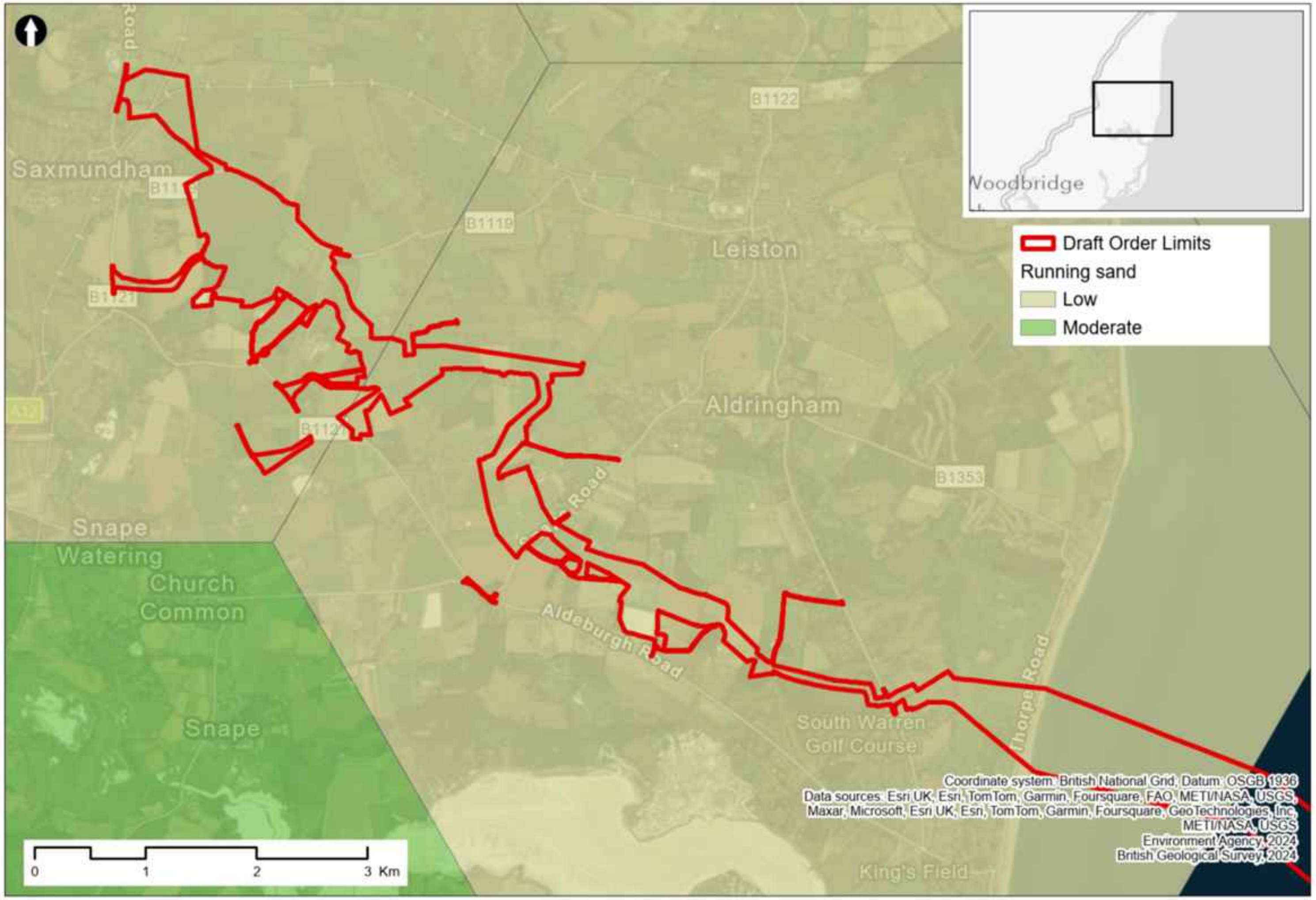


Figure A.5: British Geological Survey – landslide risk

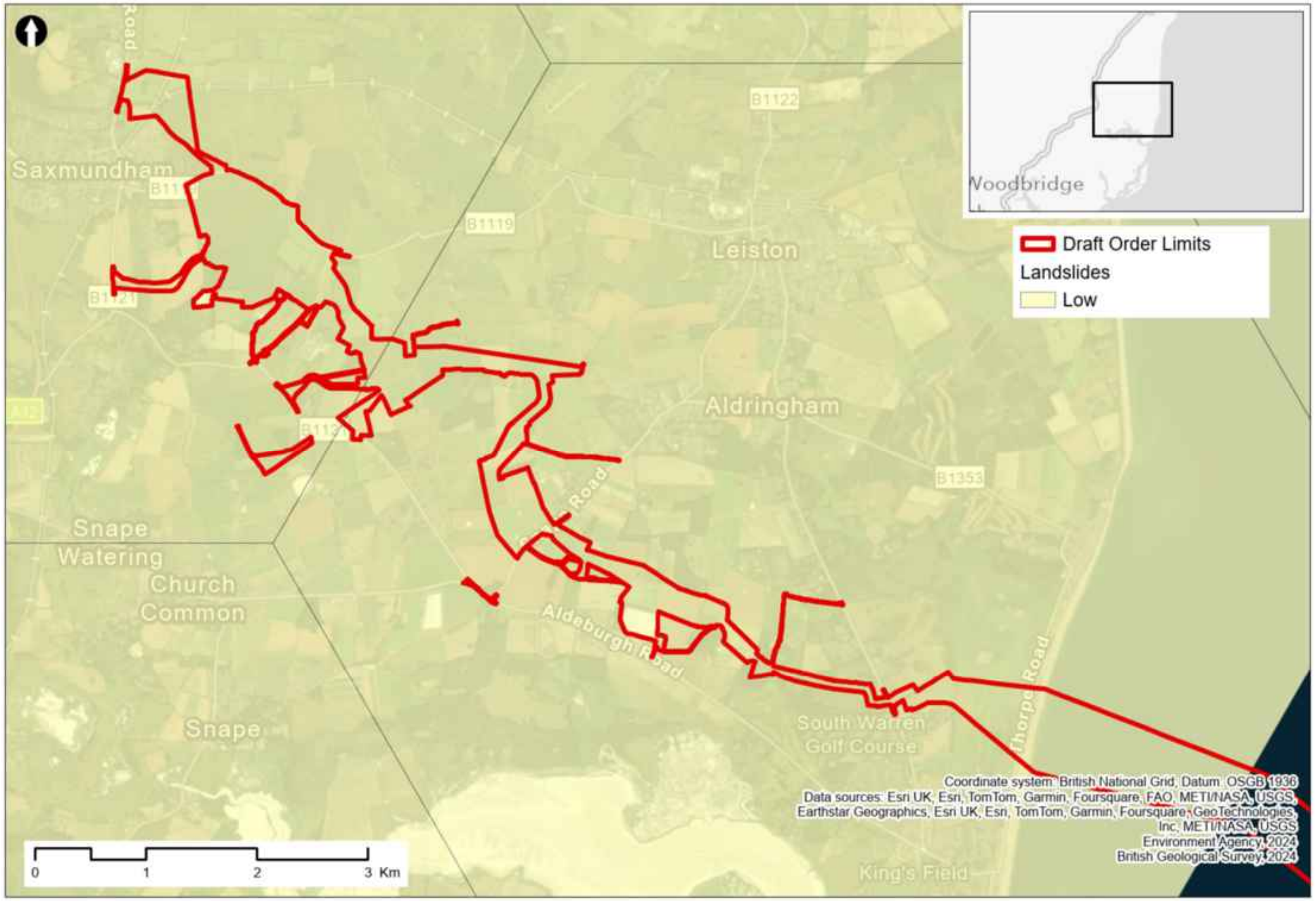


Figure A.6: British Geological Survey – compressible ground risk

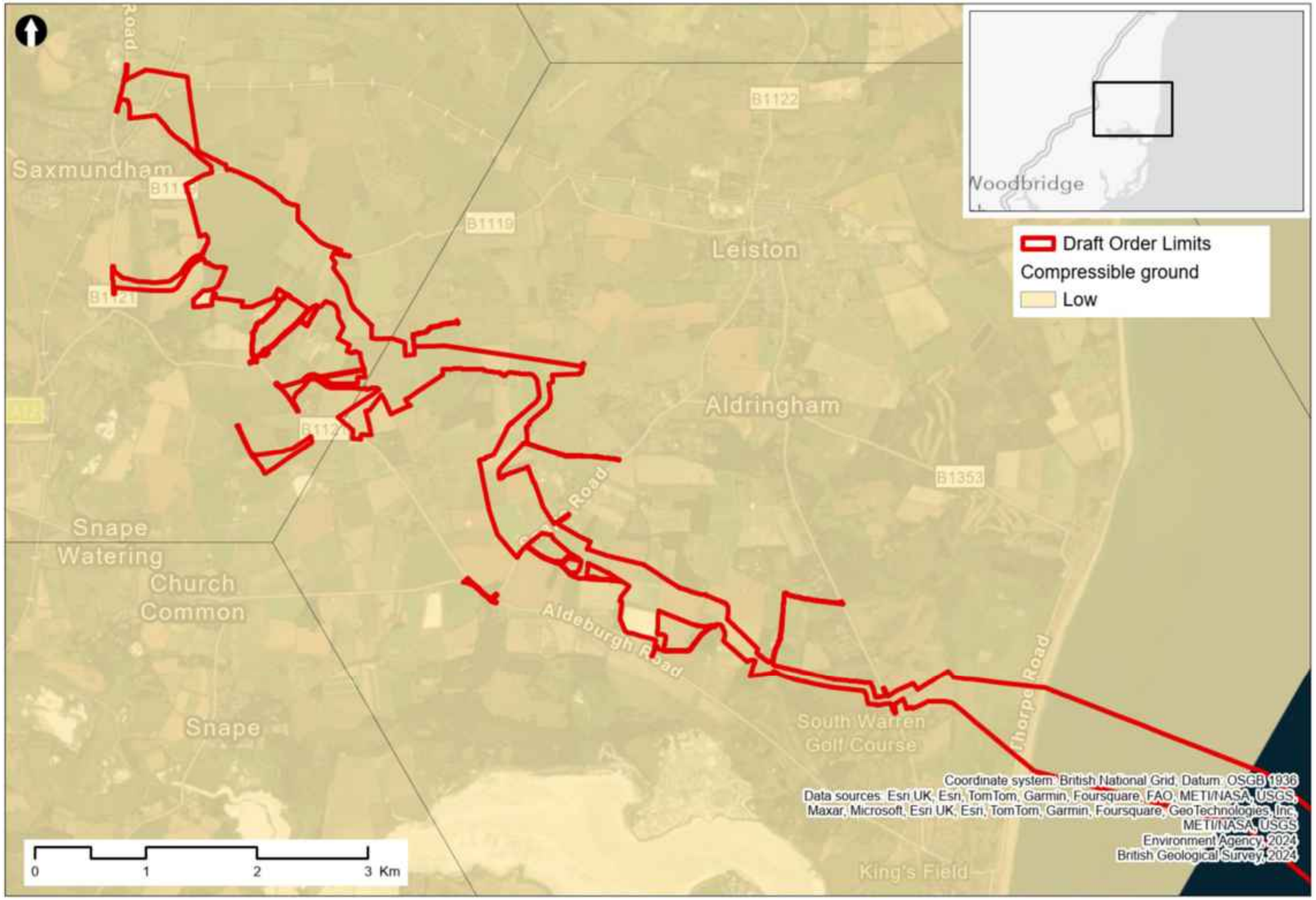


Figure A.7: British Geological Survey – collapsible ground risk

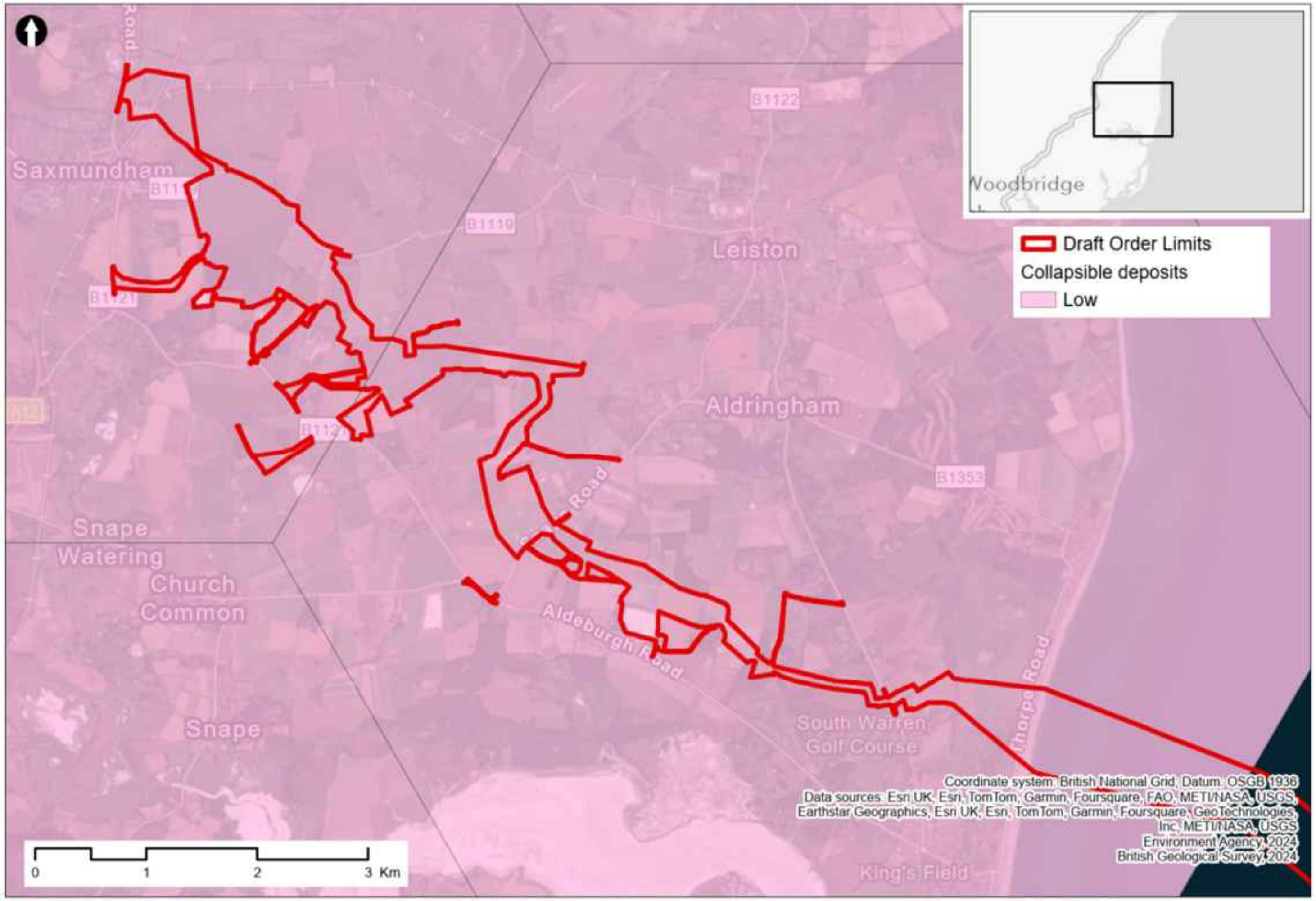


Figure A.8: British Geological Survey – Superficial thickness model (mean thickness)

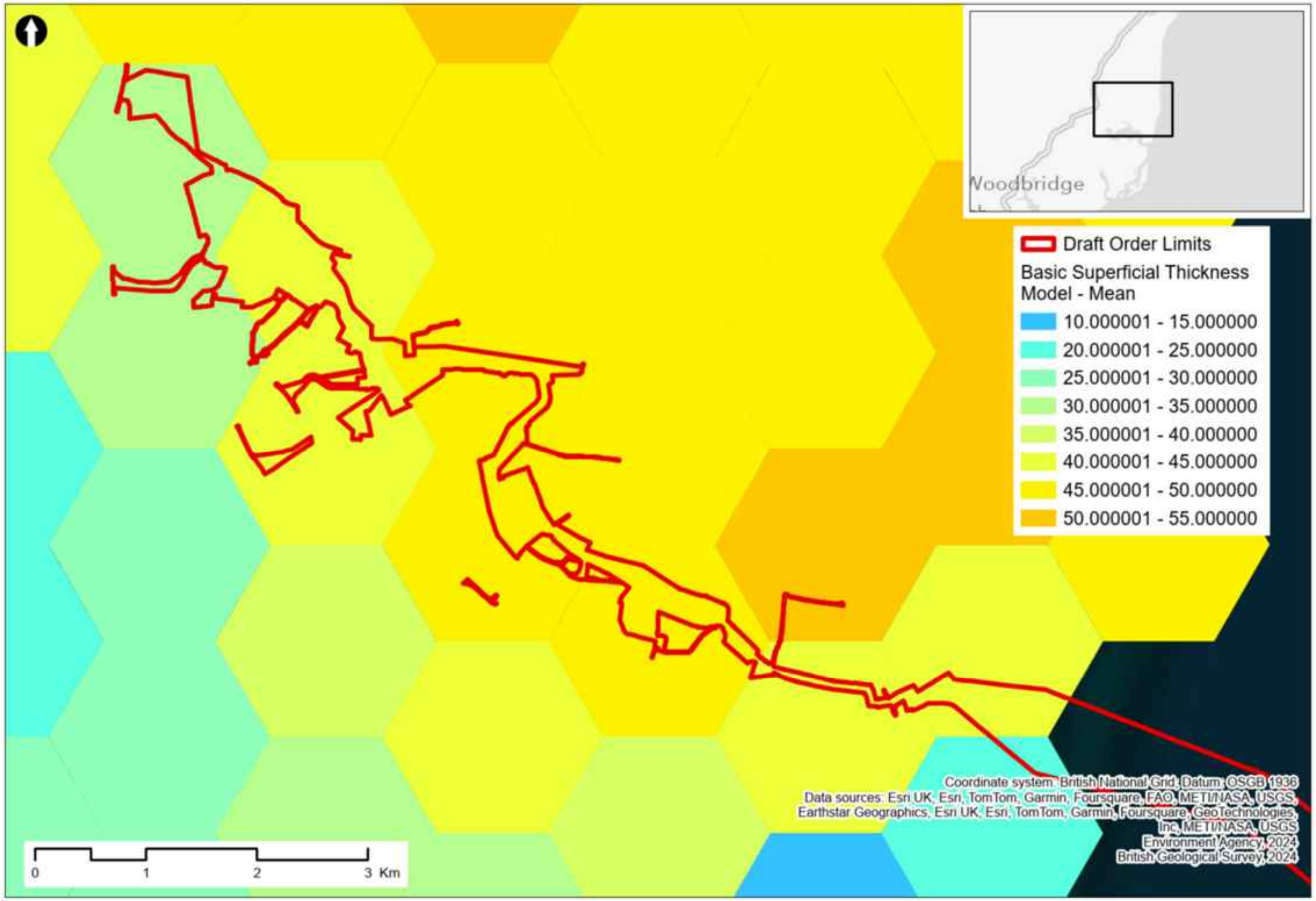
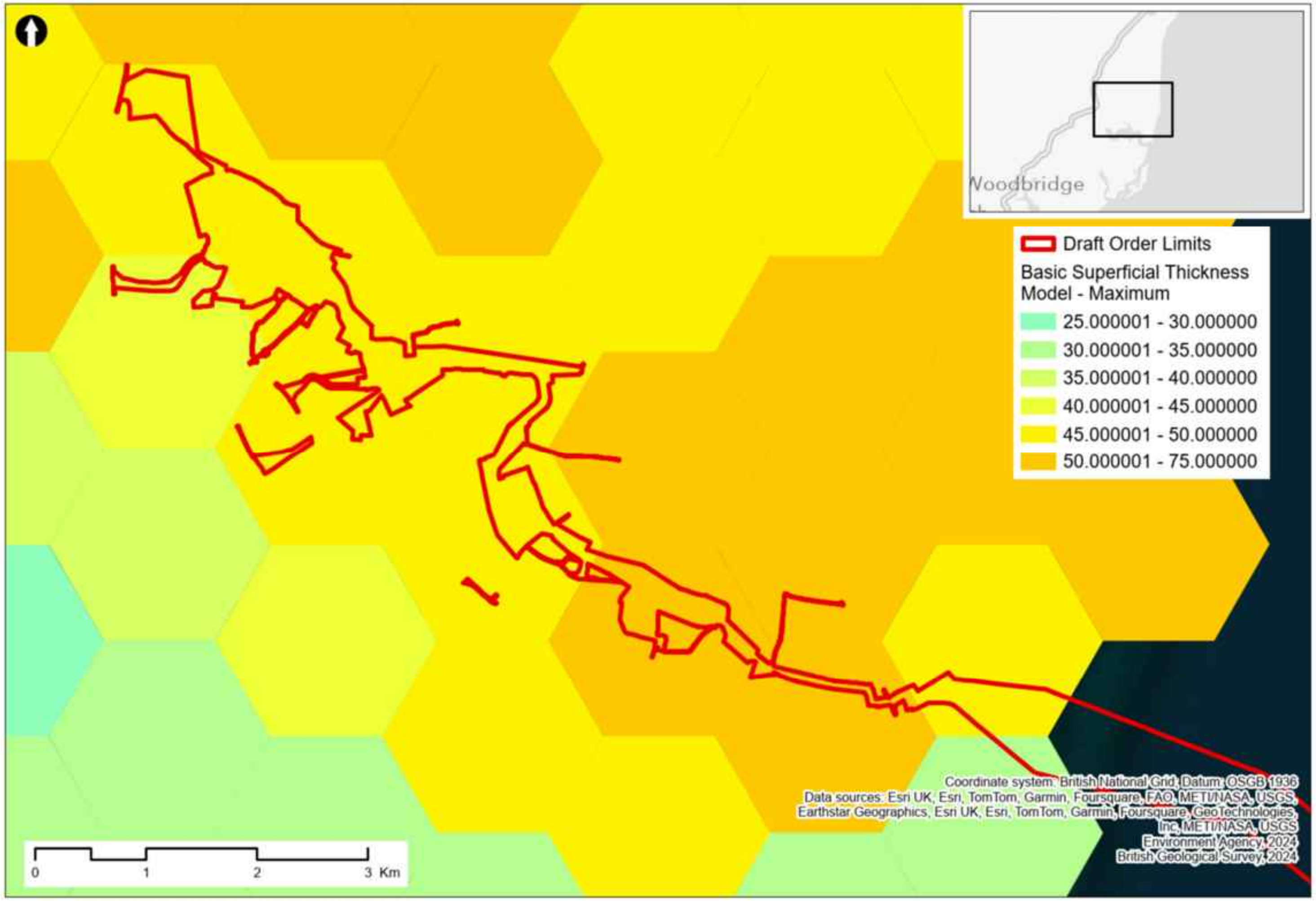


Figure A.9: British Geological Survey – Superficial thickness model (maximum thickness)



B. Ground models

This section summarises a series of ground models for relevant areas across the site. The spatial relationship of the following ground models are presented in Figure B10 and B11.

Figure B.1: Spatial relationship of ground models – Sheet 1

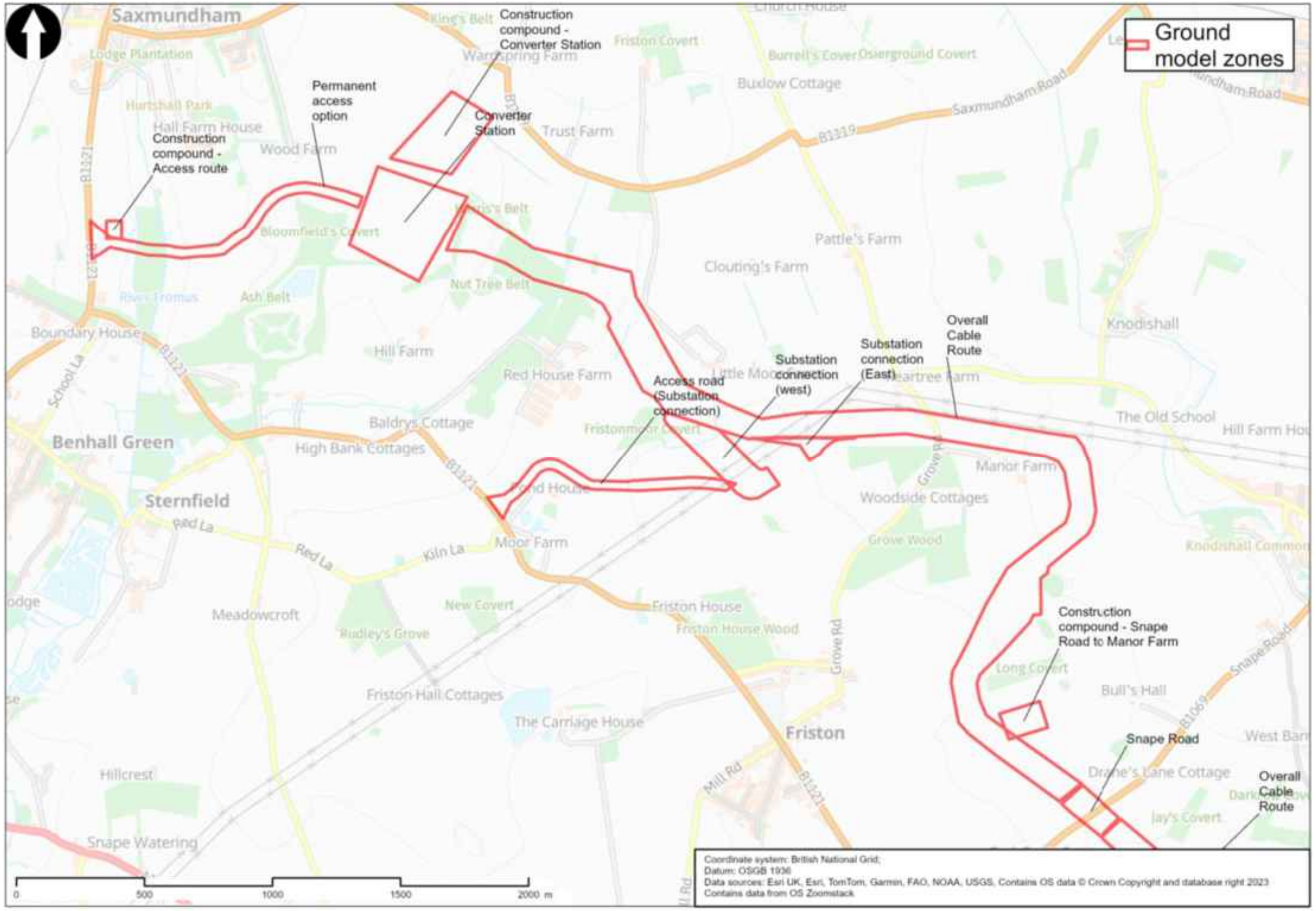
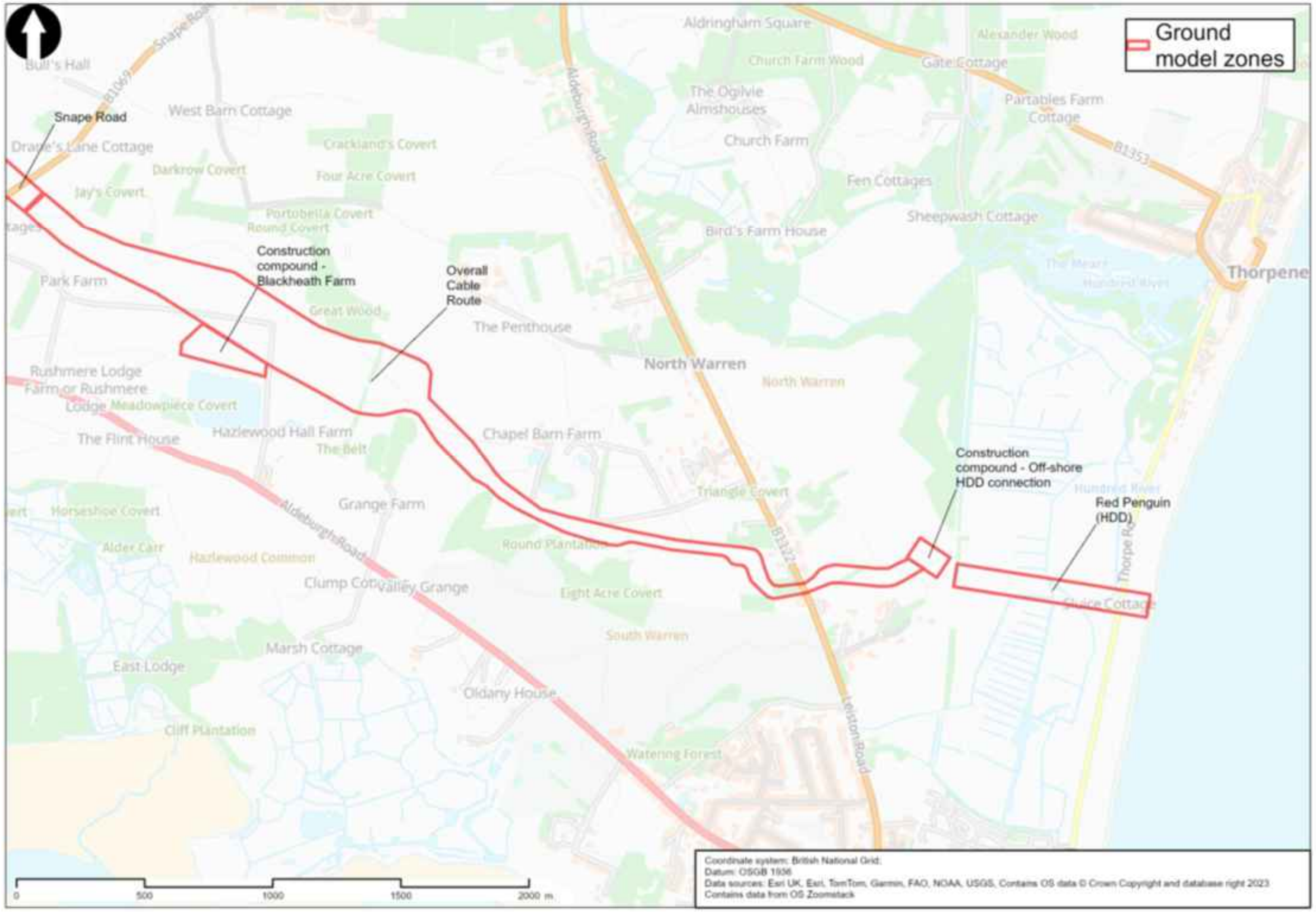


Figure B.2: Spatial relationship of ground models – Sheet 2



B.1 Converter Station

Table B.1 presents the ground model for the Converter Station. The site is surfaced with topsoil owing to its location within agricultural fields. Metres below ground level and metres above ordnance datum are presented as although the site is located at a fairly similar level across its footprint, there is anticipated to be an element of cut / fill to provide a level platform for the works.

It should be noted that following interpretation of the engineering logs and laboratory testing, it has been difficult to determine the boundary between any Lowestoft Formation – Sand and Gravel and the underlying Crag Group, therefore the depths and descriptions of these materials should be treated with caution. It is anticipated that these units are likely to be below the influence zone of the majority of design elements at the Converter Station.

Table B.1: Ground model – Converter Station

Stratum	Top depth (m bgl) [m AOD]	Bottom depth (m bgl) [m AOD]	Thickness (m)
Topsoil Crops overlying: Soft to firm dark brown to brown slightly gravelly slightly sandy CLAY to slightly clayey slightly sandy slightly gravelly SILT with occasional rootlets (>3mm diameter). Gravel is angular to rounded coarse flint, sandstone, mudstone.	0.0 [25.24 – 23.15]	0.25 – 0.35 [24.94 – 22.85]	0.25 – 0.35
Lowestoft Formation (Diamicton) Soft / firm to (generally becoming) stiff to very stiff locally friable yellowish brown becoming bluish brown to dark grey with depth slightly sandy slightly to gravelly CLAY with low cobble content (in one instance slightly sandy SILT). Pockets / lenses of fine to coarse or clayey or silty sand, rare fragments of lignite or pockets of silt. Rootlets present (<3mm diameter) throughout. Gravel is angular to rounded fine to coarse quartz, Chalk and flint. Cobbles are flint and Chalk. Occasional beds of orangish brown clayey gravelly to very gravelly fine to coarse SAND or sandy angular to rounded GRAVEL of flint and Chalk with a low cobble content of flint, between 0.25 – 0.55m in thickness. (BH310, TP311, TP313). Rare boulder sized fragments of Chalk encountered (e.g. TP310).	0.25 – 0.35 [24.94 – 22.85]	8.20 – 9.30 [16.21 – 15.28]	7.90 – 9.00
Lowestoft Formation (Sand and Gravel) Dense to very dense yellowish or orangish brown mottled dark grey / white slightly gravelly clayey fine to coarse SAND. Gravel is angular to rounded fine to medium flint and Chalk with rare shell fragments noted in BH306. In BH307, a 3.5m thick bed of very stiff slightly gravelly slightly sandy silty CLAY was recorded at 13m bgl, suggesting local variation in this unit and potential to encounter cohesive beds.	8.2 – 9.3 [16.21 – 15.28]	13.0 – 19.0 (>25[1]) [9.09 – 5.58, (>0.59[1)]]	4.7 – 9.7 (>16.8[1])
Crag Group Dense to very dense orangish brown or dark grey mottled orangish grey slightly to gravelly clayey or silty fine to coarse SAND with rare to occasional shell fragments and flasers of dark grey clay / soft grey silty nodules. Gravel is angular to rounded fine to medium flint. Locally encountered as very stiff thinly laminated grey to dark grey sandy silty CLAY with rare shell fragments (thickness not proven in BH309), and a bed 0.20m thick medium strong orangish brown moderately weathered fine to coarse SANDSTONE with iron straining – recovered as gravel / cobble sized fragments recorded in BH310.	15.7 – 19.0 [9.09 – 5.58]	>28.45** [< -3.66]	>12.75*

*Thickness not proven **Base not proven
[1] – In BH308 it was not possible to differentiate between the Lowestoft Formation Sand and Gravel and underlying Crag Group based on available information, unit thickness should therefore be treated with caution

In vicinity of the Converter Station groundwater is generally expected to be deep (c. 14 – 18m bgl), though local perched water tables may be encountered associated with granular beds within the Diamicton.

B.2 Permanent access routes

An overall summary of the ground conditions along proposed access routes are presented in Table B.2 and Table B.3, with the location of these ground models presented in Figure 5.2. The majority of exploratory holes undertaken were machine excavated trial pits, therefore these did not prove the thickness of any superficial deposits such as the Lowestoft Formation. Boreholes were undertaken in vicinity of the River Fromus to inform the river crossing design.

The geology along the access roads across the site vary due to changes in the ground conditions across the sites. An indicative cross-section through the geological conditions is presented in Section 4 for the Converter Station.

Table B.2: Ground model – Permanent access option (Converter Station)

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil Grass overlying soft / friable brown mottled orangish brown slightly gravelly sandy CLAY with occasional to frequent rootlets (>4mm), or slightly gravelly fine to medium SAND. Gravel is subangular to subrounded fine to medium flint, Chalk and limestone. Rare plastic fragments.	0 – 0.30	0.30 – 0.55	
Made Ground [interpreted to be reworked Alluvium] Soft black mottled orangish brown slightly gravelly sandy CLAY with occasional glass fragments and hydrocarbon odour / staining [Encountered in BH501 only]	0.55	0.90	0.45
Alluvium Very loose to loose dark grey mottled black or greyish brown mottled orange slightly clayey slightly gravelly fine to coarse SAND with a slight hydrocarbon odour to soft sandy clayey SILT / sandy silty CLAY with occasional shell fragments. [Encountered in vicinity of the River Fromus only – BH501, BH502 and BH502A]	0.20 – 0.90	2.00 – 2.50	1.10 – 2.30
Lowestoft Formation (Sand and Gravel) Orange to yellowish brown slightly gravelly slightly to silty or clayey fine to coarse SAND. Local low cobble content of angular flint. Occasional roots and rootlets <15mm at the top of the unit. Gravel is angular to subrounded fine to coarse flint. [TP513, TP514, TP515]]	0.30 – 3.70	>4.0	>1.95
Lowestoft Formation (Diamicton) Firm orangish brown becoming stiff to very stiff friable bluish grey slightly sandy gravelly (locally silty to very silty) CLAY with a low cobble content. Occasional bands of orangish brown to grey fine to medium sand near its top, and rare bands of brown silt at depth. Gravel is angular to rounded fine to coarse flint, Chalk, sandstone, limestone. Cobbles are angular to rounded flint and Chalk. Locally encountered with a greater granular content - including beds of gravelly silty fine sand with pockets/ lenses or clay, or clays with frequent lenses/pockets of clayey sand or silt (e.g. TP511). Not encountered in proximity of River Fromus [TP511, TP515, TP516, TP518]	0.30	>4.0	3.4 – >3.7
Crag Group	2.0 – 3.0	17.5 – 18.2	14.5 – 16.2

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Medium dense to very dense orangish brown becoming grey slightly gravelly fine to coarse locally silty or clayey SAND. Occasional flasers of brown/ bluish grey clay, and rare to frequent shell fragments Gravel is angular to subrounded fine flint, with occasional to frequent shell fragments below 2.5 – 7m bgl. Occasional gravel of siltstone between 12 – 13m bgl (BH501) Dense multicolour slightly sandy angular to subrounded fine to coarse GRAVEL of flint. Sand is fine to coarse (2.1m thick at its top in BH501 only) [Encountered in boreholes only, in proximity to River Fromus – BH501, BH502 and BH502A]			
London Clay Formation Stiff to very stiff bluish grey slightly sandy silty CLAY with occasional shell fragments. Sand is fine. [Encountered in boreholes only, in proximity to River Fromus – BH501 and BH502A]	17.5 – 18.2	>25.55**	>8.05*

*Thickness not proven **Base not proven

Groundwater was encountered close to surface in proximity of the River Fromus at c. 0.36 – 0.73m bgl, but is expected to deepen as the topography rises away from the river valley.

The ground conditions presented in Table B.3 are summarised from a series of trial pits undertaken as part of the SPR GI (see Figure 4.1 and Appendix A), in vicinity of the access route for Friston substation The following exploratory holes have been used to summarise the ground model:

- TP001 – TP007, TP012, TP013
- BH011, BH024

In TP012, the Diamicton appeared to underlay beds of the Sand and Gravel, hence potential for local variation in the top depth of the Diamicton deposit even within areas where it may not be mapped (likely due to variable depositional environment as presented in Section 2.2). Where the diamicton was recorded at surface, it was shown to be thin towards its margins, as expected based on the BGS mapping.

Table B.3: Ground model – Friston substation access route

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil Firm to stiff brown organic slightly gravelly sandy SILT, to slightly gravelly slightly to very clayey or silty fine to medium SAND. Gravel is angular to subangular fine to coarse flint and chalk	0	0.40 – 0.58	0.40 – 0.58
Made Ground Firm dark brown slightly sandy slightly gravelly CLAY with frequent roots/rootlets. Gravel is subangular to rounded fine to coarse flint, chert and brick fragments [Encountered in TP007 and TP013 only]	0	0.28 – 0.30	0.28 – 0.30
Lowestoft Formation - Diamicton Firm to very stiff grey / dark bluish grey mottled orange grey mottled red slightly sandy slightly to very gravelly silty CLAY with a low cobble	0.40 – 0.50 Locally up to 2.6	1.0 – >3.5*	0.60 – >3.0**

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
content. Locally with lenses or pockets or orangish brown clayey or silty sand. Gravel is subangular to rounded fine to coarse Chalk and flint. Cobbles are subangular flint, chert and Chalk Occasional beds of orangish brown silty fine to coarse SAND (up to 0.40m in thickness) at the top of the unit. [Not recorded in TP006]			
Lowestoft Formation – Sand and Gravel Dense orangish to yellowish brown mottled grey slightly clayey or slightly silty locally slightly gravelly fine to coarse SAND with occasional distinct gravel bands (e.g. between 0.9 – 1.2m bgl in TP0012), and occasional silt/clay bands. [Encountered in TP006, TP012, TP013, BH011, BH024]	0.30 – 0.58	2.60 – >3.5**	2.28 – 3.3 (>3.1*)
Crag Group Very dense light orangish brown very gravelly slightly silty fine to coarse SAND. Gravel is subangular to rounded fine to medium flint. [Encountered in BH024 only]	3.5	>15.0**	>11.5*

*Thickness not proven **Base not proven

Groundwater was only recorded in the Crag Group in BH024 between depths of 9.1 – 10.5m bgl.

B.3 Cable route

This section describes the ground models reviewed for the length of the cable route, including the substation connection. The location of these are presented in Figure B.1 and B.2.

Several other exploratory holes are located along the length of the route however have been presented in a separate ground model due to the nature of the proposed works and engineering descriptions of the materials, including the Snape Road where material was encountered with a greater granular content (see Section 5.1.5.2) and for individual construction compounds.

B.3.1 Cable route

The exploratory holes reviewed for the ground model along the cable route comprise both GI undertaken from 2023 as well as from the SPR investigation in 2021 from the centre of the site in vicinity of the substation (see Section 2.3, Figure 4.1 and Appendix A). A summary of the exploratory holes reviewed along the cable route are presented below.

The ground conditions expected across the length of the cable route vary as it transects several different glacial units along the length of the site, summarised in Table B.4. These are discussed later in the report where the models have been separated based on expected geology for the purpose of design.

It should be noted that the glacial deposits are variable in nature (see Section 2.2), with both cohesive and granular materials being recorded throughout the site. Due to the variability over short spatial distances, the exploratory holes from the SPR GI have been summarised separately. The following exploratory holes are reviewed in this section:

2023 GI:

- TP203 – TP205
- TP218

- TP220 – TP222A
- TP229

SPR GI (2021)

- TP056 – TP062
- WS01

In a few instances where the Lowestoft Formation – Sand and Gravel is recorded on the BGS mapping, sandy silts were present near surface. It is currently unclear but it is possible this could be associated with the clay and silt member of the formation (despite not being recorded on the BGS mapping), or this could potentially be related to variability within the sand and gravel.

Table B.4: Ground model – Cable route – 2023 GI

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Made Ground Brown slightly to gravelly silty fine to medium SAND with frequent rootlets. Gravel is angular to rounded fine to coarse flint, Chalk, mudstone, sandstone, occasional brick and pottery fragments. Suspected worked flints and arrow heads within TP222. Encountered in TP218, TP222 and TP222A only	0	0.20 – 0.95*	0.20 – >0.95**
Topsoil Grass or crops overlying brown slightly gravelly clayey or silty fine SAND locally with frequent rootlets and described as organic. Gravel is angular to subrounded fine to coarse quartz, flint and Chalk.	0	0.20 – 0.60	0.30 – 0.50
Lowestoft Formation – Diamicton At its top in TP203, WS001 Orangish brown slightly to gravelly silty fine SAND. Gravel is angular to subangular fine to coarse flint 0.50 – 0.75m in thickness Firm becoming stiff friable light greenish brown mottled orangish brown, or dark orangish brown slightly gravelly slightly to sandy locally silty CLAY. Occasional pockets of soft greenish brown silt in TP204 / TP204A. Gravel is angular to subrounded fine to coarse flint and Chalk. [TP203, TP204, TP218]	0.30 – 3.70	>4.1*	>3.60**
Lowestoft Formation – Sand and Gravel General description Yellowish or orangish brown slightly to very gravelly slightly to clayey or silty to very silty fine to coarse SAND. Local low cobble content of angular flint. Gravel is subangular to subrounded coarse quartz/quartzite, flint, Chalk. and mudstone Locally recorded as: • Soft friable orangish brown slightly gravelly sandy SILT (0.50m thickness at the top of the deposit in TP204) • Soft friable orangish brown slightly gravelly very sandy SILT of 3.4m thickness. Frequent lenses and pockets of firm friable greenish brown mottled orangish brown sandy CLAY. [TP218] TP218, TP220, TP222, TP222A	0.20 – 0.30	3.80 – >4.20*	3.50 – >3.90**
Possible Crag Group (Chillesford Church Clay Member) Stiff friable thinly laminated orangish brown mottled light grey and reddish brown slightly sandy silty CLAY with occasional iron staining. [Encountered in TP222A only]	3.80	>4.0*	>0.20**

*Base not proven **Thickness not proven

Although the Diamicton is recorded on BGS mapping across the area where the 2021 GI was undertaken summarised below, it thins where it bisects the site (see Appendix A) and appears to be slightly more variable in nature than encountered in other areas of the site, with other units of the Lowestoft Formation also likely to be present in this area of the cable route. For this reason, the 2021 SPR GI has been summarised separately in Table B.5.

Table B.5: Ground model – Cable route – 2021 SPR GI

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil Brown to dark brown slightly gravelly very silty fine to coarse SAND. Locally described as organic. Gravel is subangular to rounded fine to coarse flint	0.0	0.30 – 0.60	0.30 – 0.60
Lowestoft Formation – Diamicton Typically at its top: ● Dark orange brown very silty slightly to gravelly fine to coarse SAND with rare thin bands of soft orange brown sandy clay – 0.90m to 1.6m in thickness Overlying ● Firm to stiff light brown to orangish brown slightly to sandy slightly gravelly CLAY with occasional thick bands of orange clayey slightly gravelly fine to coarse sand in TP058. Gravel is angular to rounded fine to coarse flint and Chalk – 0.90 – 1.0m in thickness [WS001, TP058 only]	0.30 – 0.45	2.25 – 2.90	1.65 – 2.60
Possible Lowestoft Formation – Silt and Clay Soft to firm orange brown slightly gravelly sandy SILT. Slightly organic in TP062. Gravel is subrounded to rounded medium to coarse flint. [TP059 and TP062 only]	0.50	1.10 – 1.20	0.60 – 0.70
Lowestoft Formation – Sand and Gravel Orangish brown slightly gravelly silty to very silty fine to coarse SAND. Occasional pockets of silt. Gravel is subangular to rounded fine to coarse flint. In TP060, a bed of 0.40m thickness described as stiff to very stiff grey mottled cream slightly sandy gravelly SILT with rare shell fragments is recorded, with gravel of angular to rounded fine to coarse flint and chalk. [TP056, TP057, TP059, TP060]	0.30 – 2.90	>3.70* - > 5.0*	>3.05**

B.3.2 Substation connection

Exploratory holes reviewed as part of the ground model for the substation connection are from the SPR investigation in 2021 (see Section 2.3, Figure 4.1). A summary of the exploratory holes reviewed in this area of the site are presented below, with the ground model shown in Table B.6, with its extents shown in Figure B.1.

- TP013, TP024 – TP026
- BH007, H011, BH025, BH026

The Diamicton thins towards its margins as shown on the BGS 1:50,000 mapping, and is absent in the western end of the substation connection, where the Lowestoft Formation – Sand and Gravel are encountered.

It should be noted that the engineering descriptions of the Lowestoft Formation Sand and Gravel and the Crag Group can be similar and they can sometimes be difficult to distinguish on the engineering logs.

Table B.6: Ground model – Substation connection

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Topsoil Dark brown silty slightly gravelly sandy CLAY. Gravel is angular fine to coarse of flint, quartz and Chalk	0.0	0.28 – 0.40	0.28 – 0.40
Made Ground Firm to stiff dark brown slightly gravelly CLAY with frequent roots / rootlets. Gravel is subangular to subrounded fine to medium flint, chert and brick fragments [Encountered in TP013, BH025 only]	0.0	0.30 – 0.58	0.30 – 0.58
Lowestoft Formation – Diamicton Firm / Stiff to very stiff light to dark greyish or greenish brown becoming dark grey (locally mottled orange) slightly sandy slightly gravelly CLAY. Gravel is angular fine to medium Chalk. Occasional beds of orangish brown very silty sand up to 0.10m in thickness. [TP010, TP025, TP026, BH007, BH025, BH026]	0.28 – 0.58	1.50 – 3.90	1.20 – 3.17 (>3.5*)
Lowestoft Formation – Sand and Gravel Loose to dense light or dark orangish/ yellowish brown mottled yellow (locally slightly gravelly) slightly to silty or clayey fine to coarse SAND. Gravel is angular to rounded fine to coarse flint / sandstone. [TP010, TP013, TP024, BH007, BH025, BH026]	0.30 – 1.50	<3.50** – 8.50	2.20 – 3.60 >2.7*
Crag Group Medium to very dense yellowish brown to dark orangish brown slightly silty slightly gravelly fine SAND. Gravel is subangular to rounded fine to medium flint, siltstone / sandstone [BH007, BH025, BH026]	5.70 – 8.50	15.34*	>9.44**

*Base not proven **Thickness not proven

Groundwater was encountered in the Crag Group in BH025 at approximately 13.5m bgl.

B.3.3 Snape Road

Table B.7 presents the ground conditions encountered in vicinity of the Snape Road, as well as the Snape Road to Manor Farm construction compound. The Lowestoft Formation (Diamicton) is recorded on the BGS mapping, though the material encountered was variable and contained a greater granular content and sand and gravel beds than encountered elsewhere across the wider site, such as the Converter Station. This may suggest spatial variability within the deposit, which is anticipated due to its formation environment.

Table B.7: Ground model – Snape Road

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Made Ground / Topsoil Grass overlying brown slightly gravelly clayey to very clayey fine to coarse SAND with a rare plastic fragment. Gravel is angular to subrounded fine to coarse quartz and flint [Plastic fragment encountered in TP511 only]	0	0.30 – 0.50	0.30 – 0.50
Lowestoft Formation – Sand and Gravel Orangish brown slightly gravelly silty fine SAND. Locally clayey with pockets of soft greenish brown mottled orangish brown sandy CLAY. Gravel is angular to subrounded fine to coarse quartz and flint.	0.30 – 0.50	1.10 – 3.1	0.60 – 2.80
Lowestoft Formation – Diamicton	1.10 – 3.10	>4.0* – 6.0	>0.90* – 3.50

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Soft to firm (locally becoming stiff) friable greenish brown mottled orangish brown, or orangish brown slightly gravelly slightly to sandy CLAY. Frequent lenses of greenish brown clayey fine sand, occasional pockets of dark orangish brown silt [TP511], and sand bands noted throughout [BH203]. Gravel is angular to subrounded Chalk and flint.			
Possible Lowestoft Formation – Sand and Gravel Medium dense orangish brown slightly gravelly fine to coarse SAND. Gravel is subangular to rounded fine to medium flint [Encountered in BH203 only]	6.0	10.0	4.0
Possible Crag Group Very dense orangish brown gravelly fine to coarse SAND. Gravel is angular to rounded fine to medium flint [Encountered in BH203 only]	10.0	15.37*	>5.37**

*Base depth not proven **Thickness not proven

No groundwater was recorded at the time of the 2023 ground investigation.

B.3.4 Construction compounds

A series of construction compounds are proposed at the site, shown in Figure B.1 and Figure B.2 and are briefly described below from west to east across the site:

- Permanent access route (to Converter Station)
- Converter Station construction compound
  - Summarised in Appendix B, Section B.1
- Two construction compounds associated with the Friston substation
  - Summarised in Appendix B, Section B.3.2
- Snape Road to Manor Farm
  - Summarised in Appendix B, Section B.3.3
- Blackheath Farm
- Off-shore trenchless (HDD) connection

Only selected compounds were investigated as part of the 2023 GI which are summarised below. It should be noted that since the ground investigation was undertaken, design development has resulted in relocation of several of the proposed construction compounds. The ground conditions anticipated at these locations are presented in the below tables.

Several of the construction compounds are located adjacent to existing ground models or areas already summarised in this section, and this is captured above where relevant.

Permanent access route (to Converter Station)

The potential ground conditions at this construction compound are summarised below. It is indicated as being approximately 30m west of the Alluvium boundary associated with the River Fromus from BGS 1:50,000 mapping and as indicated in Appendix A, therefore there could be potential to encounter Alluvium deposits. For reference to the potential Alluvium materials, reference should be made to Section B.2 where these are summarised.

Table B.8: Ground model – Temporary construction compound – Permanent access (Converter station) (TP514)

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Made Ground / Topsoil Brown slightly gravelly fine to medium SAND with occasional rootlets. Gravel is angular to rounded flint, chalk and occasional brick fragments	0	0.35	0.35
Lowestoft Formation – Sand and Gravel Yellowish brown slightly gravelly clayey fine to medium SAND with a low cobble content. Gravel is angular to subangular fine flint. Cobbles are angular flint	0.30	>4.2*	>3.9**

*Base not proven **Thickness not proven

Blackheath Farm

The anticipated ground conditions encountered at the Blackheath Farm construction compound are summarised below.

Table B.9: Ground model – Temporary construction compound – Blackheath Farm (TP404)

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Made Ground / Topsoil Crops overlying dark brown slightly gravelly silty fine SAND. Rare wooden fence post (600 x 509 x 50mm). Gravel is angular to subangular fine to coarse Chalk and flint	0	0.30	0.30
Lowestoft Formation – Sand and Gravel Dark orangish brown becoming orangish brown mottled yellowish brown slightly clayey gravelly fine to coarse SAND with a low cobble content. ~Cobbles are subangular flint	0.30	>4.2*	>3.9**

*Base not proven **Thickness not proven

Offshore trenchless (HDD) connection

The anticipated ground conditions encountered at the off-shore HDD connection at the eastern end of the cable route are summarised below. It should be noted that no exploratory holes were undertaken within the footprint of the construction compound, and it is anticipated that the Crag Group may be encountered in the footprint of the compound. Its engineering description is anticipated to be similar to the Lowestoft Formation – Sand and gravel, though this should be treated with caution subject to site-specific confirmation.

Table B.10: Ground model – Temporary construction compound – Offshore HDD connection (TP222A)

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Made Ground Grass overlying brown slightly gravelly silty fine SAND with a low cobble content. Gravel is subangular to subrounded fine to coarse flint, quartz, limestone, pottery fragments and brick. Cobbles are angular flint.	0	0.30	0.30
Lowestoft Formation – Sand and Gravel Orangish brown gravelly slightly silty fine to coarse SAND. Gravel is angular to subrounded fine to medium flint and quartzite.	0.30	3.80	3.50
Chillesford Church Clay Member (Crag Group)	3.80	>4.0*	>0.20**

Stratum	Top depth (m bgl)	Bottom depth (m bgl)	Thickness (m)
Stiff friable thinly laminated orangish brown mottled light grey / reddish brown slightly sandy silty CLAY with occasional iron staining.			

*Base not proven **Thickness not proven

B.4 Trenchless crossings (HDD)

This section summarises ground models in areas where trenchless crossings (i.e. HDD) is proposed.

B.4.1 Red Penguin

Three boreholes (RedP-BH-1, 1A and 4) were undertaken as part of the on-shore scope to inform the HDD alignment at the landfall area, linking between on and off-shore. Red Penguin are responsible for the design of the HDD and off-shore elements, and these two boreholes were included within the on-shore ground investigation undertaken in 2023 to inform their design.

The location of the exploratory holes is shown in Figure B.2, with a summary of the ground conditions encountered from these locations is presented in Table B.11.

Table B.11: Ground model – Red Penguin HDD

Stratum	Top depth (m bgl) [m AOD]	Bottom depth (m bgl) [m AOD]	Thickness (m)
Topsoil Orangish brown slightly gravelly fine to coarse SAND with rootlets (<2mm). Gravel is subangular to subrounded fine to medium chert. [Encountered in RedP-BH-4 only]	0 [4.62]	0.35 [4.27]	0.35
Made Ground Brown to black sandy angular to rounded fine to coarse GRAVEL with fragments of brick, glass, ceramic, concrete and occasional shell fragments. [Not encountered in RedP-BH-4]	0 [2.66 – 2.70]	1.50 - >2.50* [1.20 to >0.16**]	1.5 – 2.5**
Marine Beach Deposits Medium dense dark brown mottled multicoloured sandy subangular to rounded fine to coarse GRAVEL with occasional shell fragments	1.5 [1.2]	3.5 [-0.80]	2.0
Tidal Flat Deposits Very soft to soft grey mottled black CLAY with occasional shell fragments, staining and slight hydrocarbon odour. – 1.7m thick, overlying Spongy fibrous black PEAT with a strong hydrocarbon odour and staining – 1.5m thick	3.5 [-0.80]	6.75 [-4.05]	3.25
Possible Marine Beach Deposits Medium dense dark grey slightly sandy rounded fine to coarse GRAVEL with staining and slight hydrocarbon odour	6.75 [-4.05]	9.50 [-6.80]	2.75
Coralline Crag Formation Medium to very dense orange / orangish brown becoming light/ dark grey slightly clayey gravelly fine to coarse SAND with occasional to frequent shell fragments. Gravel is angular fine to coarse cemented sand and occasional cemented shells. Bed 0.1m thick of very stiff friable orangish brown mottled black and grey very sandy SILT with slight organic odour	0.35 – 9.5 [4.27 – -6.80	20.50 – 24.70 [-15.88 to -22.00]	15.50 – 20.15
London Clay Formation	20.50 – 24.70	>29.95* [<27.25*]	>9.95**

Stratum	Top depth (m bgl) [m AOD]	Bottom depth (m bgl) [m AOD]	Thickness (m)
Firm becoming stiff to very stiff closely to very closely fissured dark grey CLAY. Slightly gravelly at its top.	[-15.88 to -22.00]		

*Base depth not proven **Thickness not proven

Groundwater was found to be tidally influenced in this area, with depths ranging between 1.26 – 2.33m bgl (1.44 – 0.37m AOD) during monitoring periods. Reference should be made to Section 5.11 which includes groundwater diver data. At the time of writing the diver monitoring is on-going.

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