Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 4, Annex 3.2: Selection and Refinement of Offshore Infrastructure

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Version A

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Glossary

Term	Definition
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.

Term	Definition
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Impact Assessment (EIA) Report.
Electrical Infrastructure Study Area	The study area between the onshore substation and offshore array area
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Project Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Export cable corridor (ECC) search area	The broad offshore corridor of seabed (seaward of the MHWS) and land (landward of MHWS) from the Hornsea Project Four array area to the Creyke Beck National Grid substation considered within this Scoping Report, within which the refined ECR corridor will be located.
High Voltage Alternating Current (HVAC)	High voltage alternating current is the bulk transmission of electricity by alternating current (AC), whereby the flow of electric charge periodically reverses direction.
High Voltage Direct Current (HVDC)	High voltage direct current is the bulk transmission of electricity by direct current (DC), whereby the flow of electric charge is in one direction.
Ørsted Hornsea Project Four (UK) Ltd.	The proposed Ørsted Hornsea Project Four (UK) Ltd. offshore wind farm project; the term covers all elements within the Development Consent Order (i.e. both the offshore and onshore components). Hereafter referred to as Hornsea Four.
Maximum design scenario	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
BAP	Biodiversity Action Plan
BRAG	Black, Red, Amber, Green (Assessment Criteria)
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
Coxx	Commitment (followed by number)
CPA	Closest Point of Approach
CPO	Compulsory Purchase Order
DBA	Desk Based Assessment
DCO	Development Consent Order
DP	Dynamic Positioning
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EISA	Electrical Infrastructure Study Area
HDD	Horizontal Directional Drilling
HER	Historic Environment Record
IFCA	(Association of) Inshore Fisheries and Conservation Authorities
MCZ	Marine Conservation Zone
MHW	Mean High Water
MLW	Mean Low Water
MoD	Ministry of Defence
MWLS	Mean Low Water Spring
NSIP	Nationally Significant Infrastructure Project
OFTO	Offshore Transmission Owner
OnSS	Onshore Substation
OS	Ordnance Survey
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
RPSS	Route planning and site selection
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SCI	Site of Community Importance
SMP	Shoreline Management Plan
SoCC	Statement of Community Consultation
SPA	Special Protected Area
SSSI	Site of Special Scientific Interest
TCE	The Crown Estate
TJB	Transition Joint Bay
UK	United Kingdom
UKC	Under Keel Clearance
UXO	Unexploded Ordnance

Units

Unit	Definition
km	Kilometre(s)
m	Metre(s)
m/yr	Metre(s) per year

1 Introduction

1.1 Background

1.1.1 Overview of Hornsea Four Approach

1.1.1.1 The Hornsea Four route planning and site selection (RPSS) process has followed an iterative approach to ensure the most appropriate solution was identified efficiently, with due consideration of environmental, technical and commercial matters. The five key stages are shown in Table 1.

Table 1 Hornsea Four Route Planning and Site Selection Stages

Stage	Associated Document
Stage 1: Identification of the AfL and Grid Connection	ES Volume 1 Chapter 3
Stage 2: Identification of an Electrical Infrastructure Study area	ES Volume 1 Chapter 3
Stage 3: Identification of the Landfall	ES Volume 4 Annex 3.1
Stage 4: Identification of the Onshore Substation (OnSS) site	ES Volume 4 Annex 3.3
Stage 5: Identification of the Offshore and Onshore Export Cable Corridor (ECC)	ES Volume 4 Annex 3.2 and Annex 3.3

1.1.1.2 The Hornsea Four Electrical Infrastructure Study Area (EISA) is largely defined by the AfL (location of the wind farm array) and grid connection point at Creyke Beck (location of the OnSS). These two locations formed the eastern and western extents of the EISA.

1.1.1.3 The EISA has been used to structure the RPSS reporting format, with:

- Landfall covered in Annex 3.1,
- all Hornsea Four offshore infrastructure east of landfall covered in Annex 3.2; and
- all Hornsea Four onshore infrastructure to the west detailed in Annex 3.3.

This is shown in Figure 1.

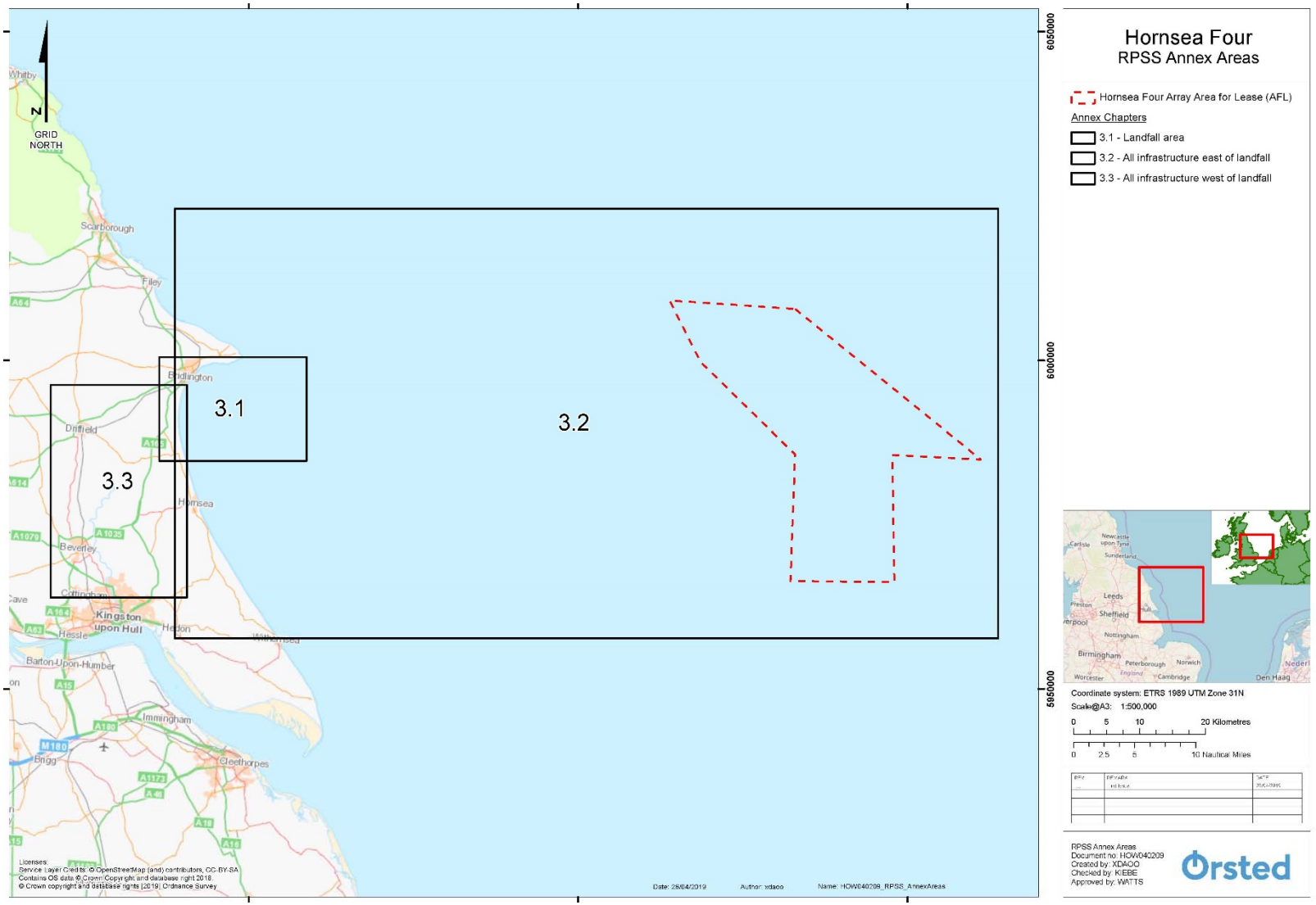

Figure 1. Hornsea Four RPSS reporting.

1.1.2 Hornsea Four Programme and Timeframes

1.1.2.1 The RPSS process has been structured incrementally, with early and frequent stakeholder engagement prioritised, through public consultation, landowner liaison and regular stakeholder correspondence. This is set out in **Table 2**.

1.1.2.2 The RPSS process specific to landfall is shown in **Figure 2**.

Table 2 Hornsea Four RPSS Programme

Stage	Description
EIA Scoping October 2018	• 2,000 m onshore ECC scoping boundary and indicative 200 m permanent ECC and 700 m temporary works area. • Onshore Substation (OnSS) search area. • Landfall search area. • 3,000 m offshore ECC scoping boundary.
Scoping – PEIR consultation	• Feedback and comments from informal public consultation events, landowner liaison and stakeholders on the scoping report and scoping boundary.
PEIR July 2019	• 80m onshore ECC inclusive of permanent and temporary works areas with indicative construction access points. • OnSS site. • Two landfall options. • 1,500 offshore permanent ECC with 500m temporary works areas buffer either side of ECC).
Section 42 and 47 consultation	• Feedback from stakeholders and members of the public upon receipt of more detailed environmental assessment work will further inform the RPSS process.
DCO Application Q2 2020	• Onshore ECC (80m) which will contain all permanent (electrical cables and Transition Joint Bays (TJBs)) and temporary works for construction works and soil storage. The details of which will be developed during detailed design. • Compounds: logistics, Horizontal Directional Drilling (HDD) and/or storage compounds outside of the permanent cable corridor for auxiliary works. • Access: Area required for access (temporary or permanent) to the construction and/or operation and maintenance activities. • OnSS: preferred site within the onshore substation search area. • Landfall: preferred site within the landfall search area. • Offshore ECC (1,500 m): the area within which the export cable route and temporary works area (500m buffer either side of ECC) are planned to be located.

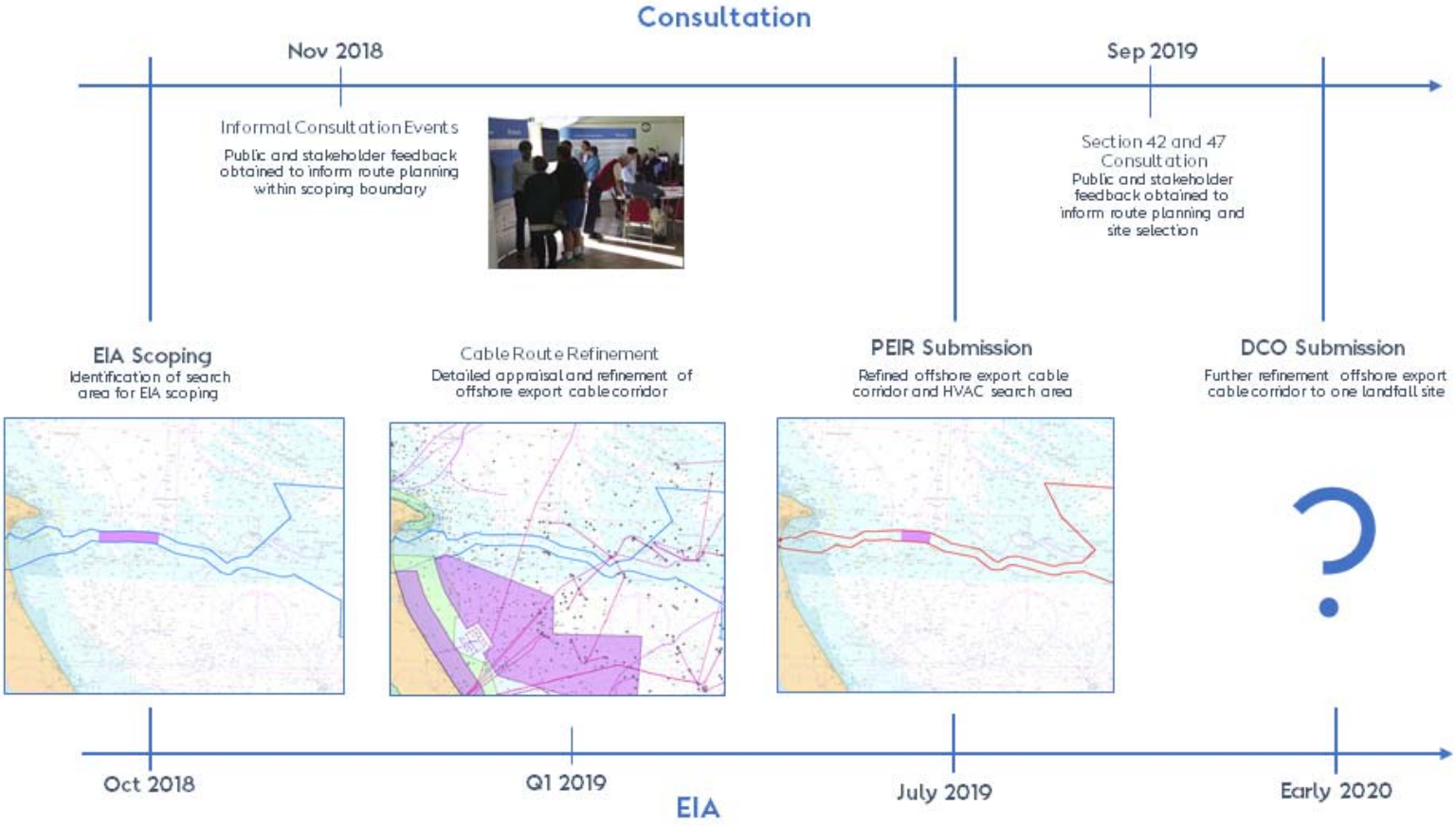

Figure 2. Offshore Export Cable Route Planning and Site Selection Timeline.

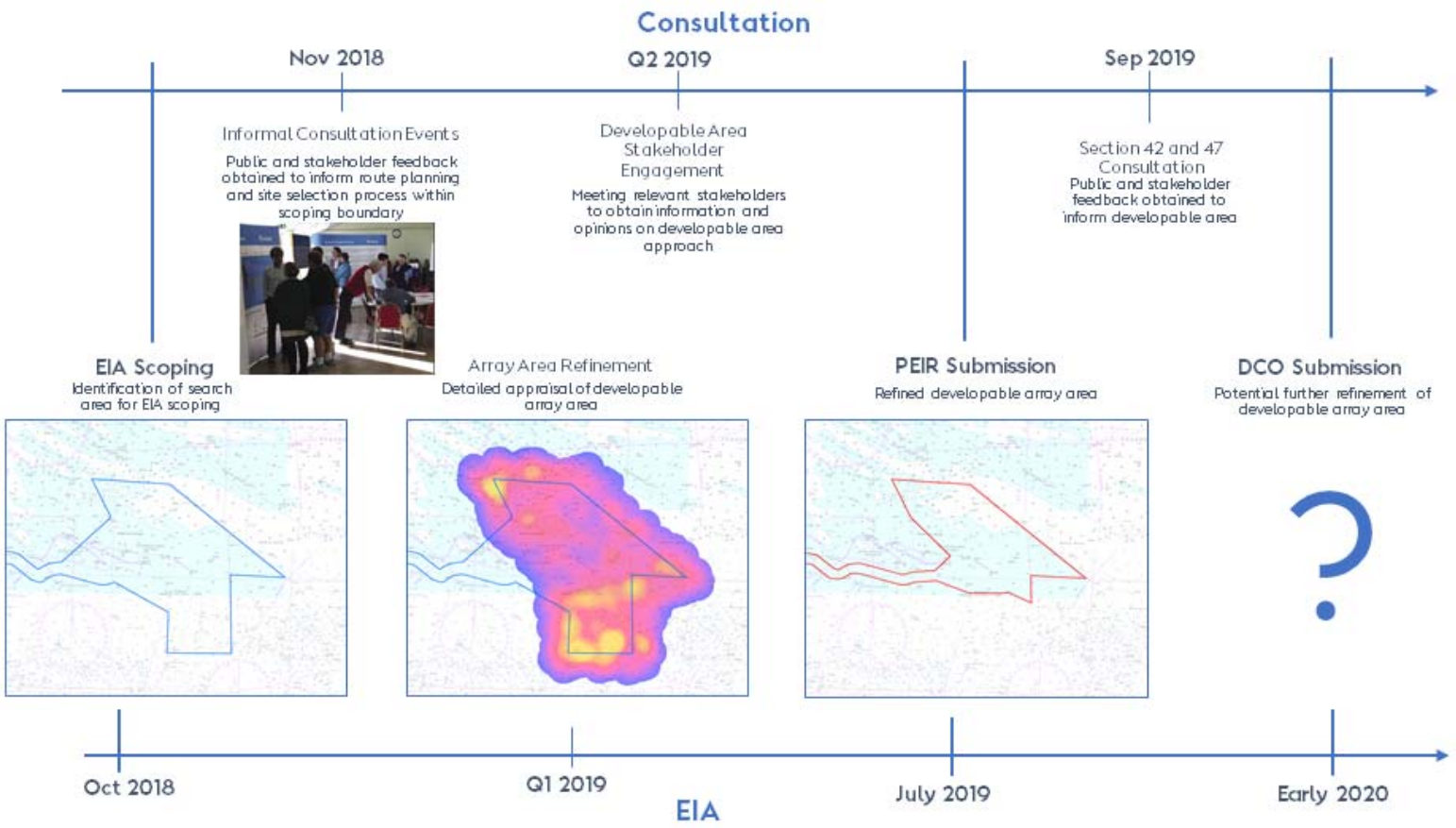

Figure 3. Offshore Array Site Selection Timeline.

1.2 Purpose of the Annex

1.2.1.1 This Annex has been produced by Ørsted Hornsea Project Four (UK) Ltd (hereafter referred to as Hornsea Four) to document the decision making behind the refinement of the offshore infrastructure since identification of the EISA up to submission of the Preliminary Environmental Information Report (PEIR). The offshore project element comprises all infrastructure seaward of the landfall (as shown in **Figure 1**). This Annex documents the following project elements:

- Stage 5 – Identification of the Offshore ECC.

1.2.1.2 Prior to submission of the PEIR the Applicant has engaged with a range of stakeholders with regards to the progress of the project and emerging project design matters. Stakeholders that were consulted as part of the ongoing RPSS process, from project inception to PEIR submission, included:

- The Planning Inspectorate;
- East Riding of Yorkshire Council;
- The Environment Agency;
- Natural England;
- Highways Agency;
- The Wildlife Trust;
- Landowners;
- Parish Councils; and
- Members of the public at local information events held in East Riding and surrounds during October 2018 (see Statement of Community Consultation (SoCC)).

1.3 Project Elements

1.3.1.1 The Hornsea Four offshore electrical transmission system will consist of up to six offshore export cables and up to three offshore booster substations to collect and transport power produced at the wind turbines to the UK electricity transmission network within a 1.5 km ECC.

2 Site Selection Methodology

2.1 Introduction

2.1.1.1 Offshore ECC routing is a minimisation exercise to identify the shortest possible route from the offshore Agreement for Lease (AfL) area to the selected landfall site, whilst avoiding constraints dictated by engineering limitations, physical, third-party, environmental and existing seabed users.

2.1.1.2 The aim of the process is to establish indicative preliminary routes for the offshore ECC, through baseline data collection and a staged refinement approach (as described in this Annex) in order to identify a route of sufficient confidence to commission site specific surveys. A preferred 1.5 km offshore ECC is then taken forward through the EIA process,

which provides sufficient flexibility within it to enable micro siting refinement following receipt of site-specific survey outputs and stakeholder feedback.

2.2 Study Area

2.2.1.1 The offshore EISA is largely defined by the AfL (location of the wind farm array) and landfall location. These two locations formed the eastern and western extent of the EISA as illustrated in **Figure 4.**

2.3 Guiding Principles

2.3.1.1 The following guiding principles and commitments for route planning and site selection have been implemented:

- select the shortest route (hence reduce environmental impacts by minimising footprint and electrical transmission losses (most efficient project));
- avoid key sensitive features where possible and where not, seek to mitigate impacts, supported by the following commitments:
  - Co44: The Holderness Inshore Marine Conservation Zone (MCZ) will be avoided by the offshore export cable corridor including the associated temporary works area;
  - Co45: The Holderness Offshore Marine Conservation Zone (MCZ) will be avoided by the offshore export cable corridor including the associated temporary works area;
  - Co86: The offshore export cable corridor and cable landfall (below MHWS) will avoid the Greater Wash SPA, Flamborough & Filey Coast SPA and the Flamborough Head SAC;
  - Co140: Archaeological exclusion zones (AEZs) will be established in the Marine WSI in accordance with the outline Marine WSI (document reference F2.4), to protect any known / identified marine archaeological receptors.

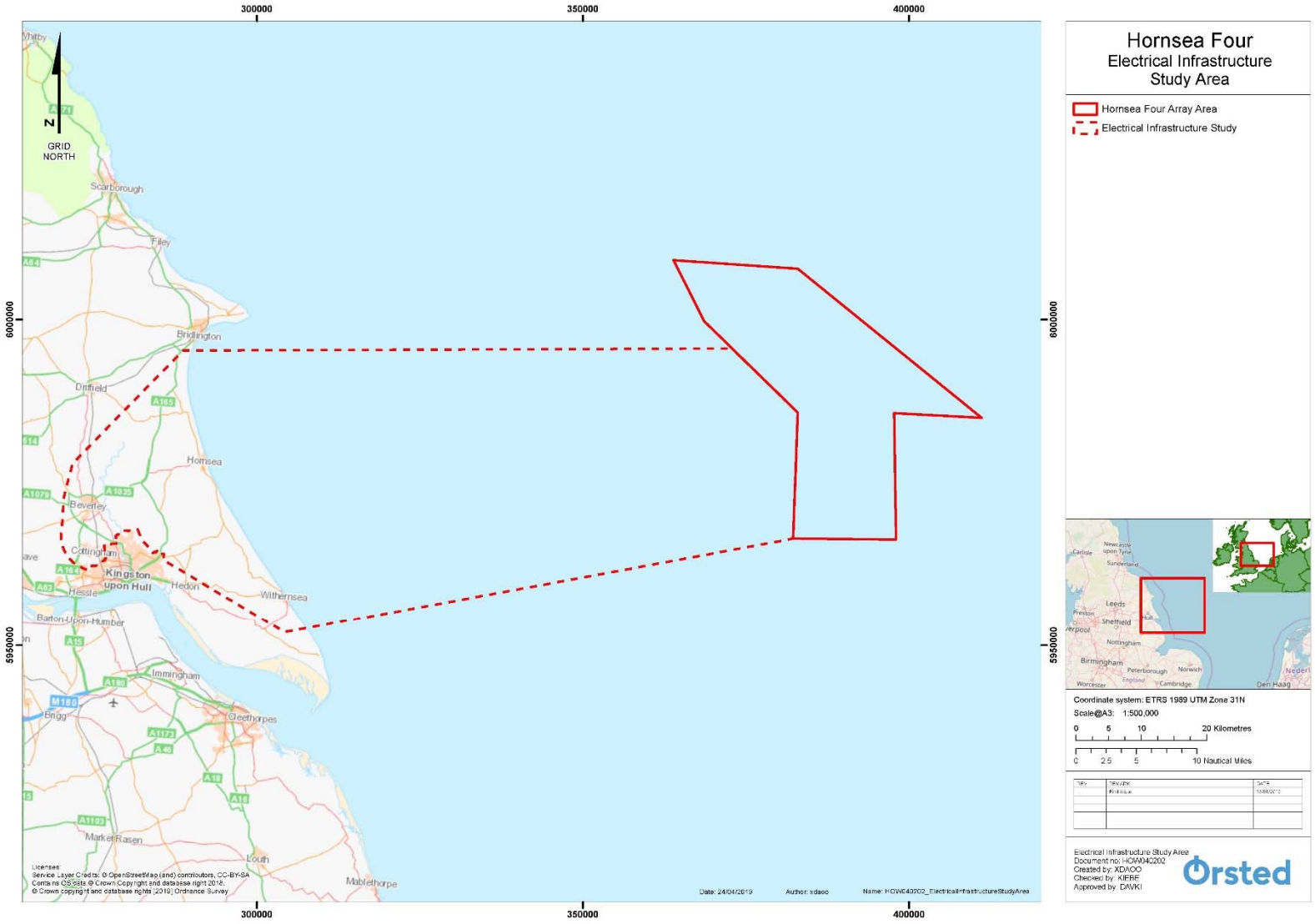

Figure 4. Hornsea Four Electrical Infrastructure Study Area.

2.4 Baseline Data & Constraint Mapping

2.4.1.1 Seeking to minimise interaction with physical constraints such as offshore cables and pipelines played a key part in establishing indicative Offshore ECC options. These options were then refined, taking account of obstructions such as surface and subsurface infrastructure, aggregate areas and sensitive environmental areas.

2.4.1.2 The following considerations were general principles used throughout the site selection process to determine appropriate route options.

2.4.2 Seabed Bathymetry

2.4.2.1 Figure 5 provides detail of bathymetric features within the EISA. The largest sandwaves observed to the north west of the AfL were considered to pose a potential technical constraint and were avoided where possible.

2.4.3 Physical and Infrastructure

2.4.3.1 Figure 5 provides detail of the existing offshore infrastructure within the EISA.

2.4.3.2 Minimising the level of interference with obstacles and hazards is a key constraint in areas that are highly developed / utilised.

2.4.3.3 Physical constraints such as ground conditions, wrecks, excessive slopes, shallow water and depressions can each be avoided through route refinement. There are certain third-party obstacles that are linear in nature (such as cables and pipelines) that can be crossed. If the export cables must cross third-party infrastructure both the asset and the installed infrastructure must be protected. A balance needs to be struck depending on the potential for additional cost and increase risk of owner conflict therefore the number of crossings is minimised where possible.

2.4.3.4 When approaching an obstacle, the turning radius of the burial tool and installation vessel must be considered. This is critical when approaching an asset that needs crossing in order to reach an optimal crossing angle of 90 degrees, allowing for sufficient linear distance for the cable to ride out prior to the crossing itself and to bed back in afterwards.

2.4.3.5 There are also other third-party features which, although they can be crossed, should be avoided to minimise risk to the cable – these include, but are not restricted to, anchorage areas and navigation aids. Areas exploited by human activity that could increase both the risk to the cable during operation and be a source of conflict during installation were considered and avoided in route development. In certain instances, such as shipping routes and fishing grounds, total avoidance is not possible and conflict can be mitigated.

2.4.3.6 Table 3 presents the physical and third-party constraints considered along with a preference of mitigation.

Table 3. Physical & Third-Party Constraints

Constraint	Preference	Mitigation
Challenging Ground Conditions	Avoid	Correct tool selection, reduced burial
UXO	Avoid	Survey and re-routing
Military PEXA	Avoid	Re-route
Dredging Areas	Avoid	Re-route
Munitions Dumping Grounds	Avoid	Re-route
Wrecks	Avoid	Re-route
Navigation Aids	Avoid	Re-route
Boulders	Avoid	Re-route, clearance
Cable Crossings	Avoid, minimise	Re-route, crossing agreements
Cables in Proximity	Avoid, minimise	Re-route, proximity agreements
Pipeline Crossings	Avoid, minimise	Re-route, crossing agreements
Pipelines in Proximity	Avoid, minimise	Re-route, proximity agreements
Offshore Infrastructure	Avoid, maintain distance	Re-route, proximity agreements
Shallow Water	Avoid	Re-route, vessel selection
Seabed Depressions	Avoid	Re-route, installation tool selection
Seabed Mobility	Avoid	Re-route, installation tool selection
Seabed Sandwaves	Avoid	Re-route, installation tool selection
Seabed Slopes	Avoid	Re-route, installation tool selection
Dumping Grounds	Avoid	Re-route, dredging
Foul Grounds	Avoid	Re-route, ground investigation
Anchorage Areas	Avoid	Re-route, deeper burial, move anchorage
Nature Conservation Designated Sites	Avoid	Re-route
Potential Annex I Habitats	Avoid	Re-route
Fish Spawning Grounds	Avoid	Mitigate through design
Commercial Fishing Grounds	Avoid	Stakeholder engagement
Planned Developments	Manageable	Stakeholder engagement
Traffic Separation Systems	Manageable	Stakeholder engagement
Shipping Routes	Manageable	Stakeholder engagement

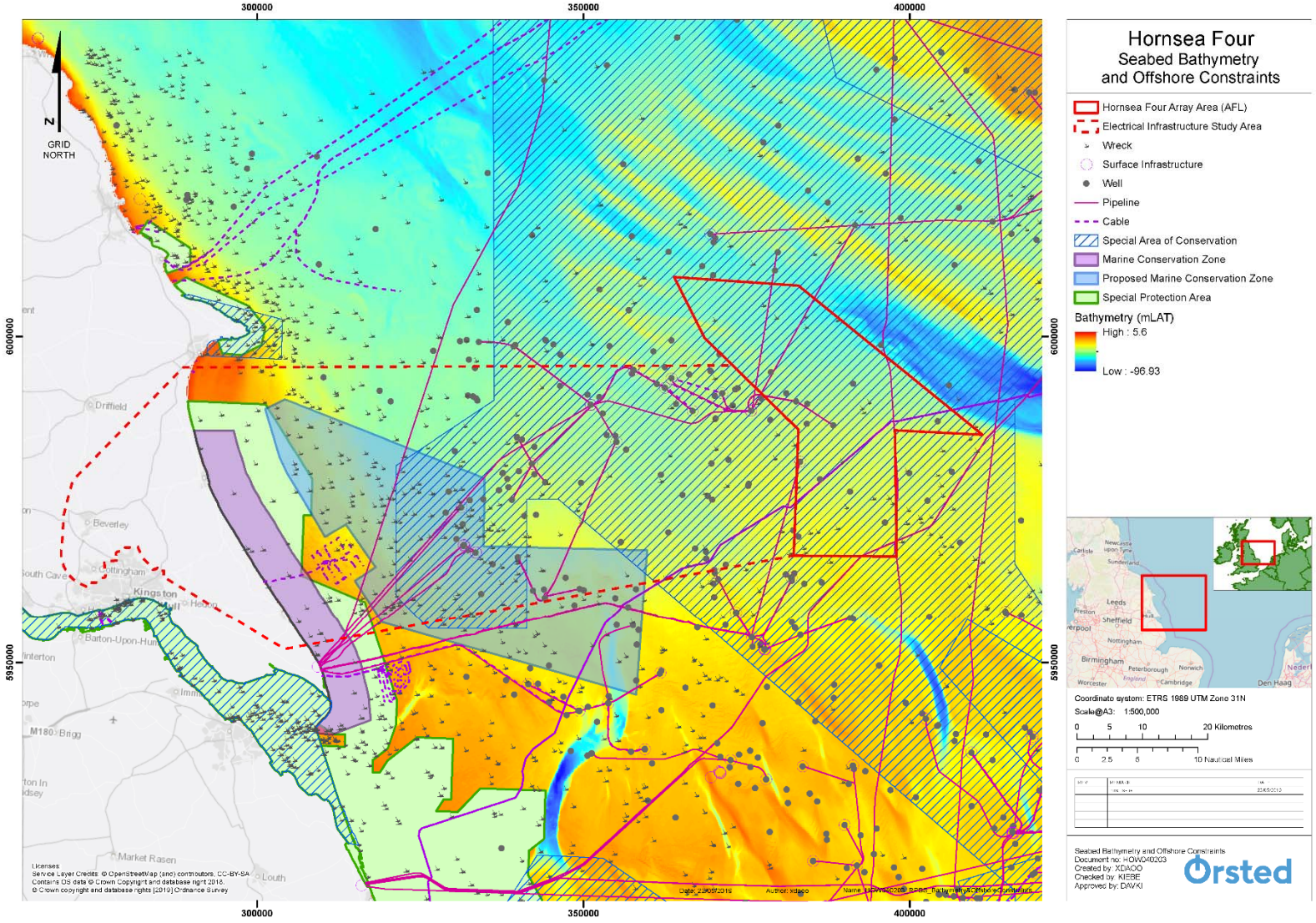

Figure 5. Hornsea Four Offshore Seabed Constraints.

2.4.4 Environmental

2.4.4.1 There were a range of European and nationally protected sites within the EISA. Engineering solutions can in some cases mitigate or minimise impacts upon environmentally sensitive areas.

2.4.4.2 Whilst nature conservation designations were not viewed as a defining factor in the early stages of route selection, as discussed later within this Annex, attempts were undertaken to avoid major designated areas.

2.4.4.3 Table 4 presents the environmental constraints considered along with a preference of mitigation.

Table 4. Environmental Constraints

Constraint	Preference	Mitigation
Foul Ground	Avoid if possible	Re-route, soil investigation
Designated sites of nature conservation interest (MCZ, SAC, SPA)	Avoid if possible	Mitigate through design and micro siting
Potential Annex I habitat (reef and sandbank)	Avoid if possible	Mitigate through design and micro siting
Ground Conditions (Soft)	Manageable	Correct cable burial tool selection, reduced burial
Ground Conditions (Hard)	Manageable	Correct cable burial tool selection, reduced burial

3 Initial Selection of Offshore ECC Study Area

3.1 Considerations

3.1.1.1 A number of fundamental principles are inherently applied to the decision-making process throughout route planning and these comprise:

- Shortest route preference for cable routing to minimise impacts my minimising footprint for the offshore and onshore cable routes as well as minimising cost (hence ultimately reducing the cost of energy to the consumer) and transmission losses;
- Avoidance of key sensitive features where possible and where not, seek to mitigate impacts;
- Minimise the disruption to populated areas; and

- The need to accommodate the range of technology sought within the design envelope and exclude those options outwith the envelope.

3.1.1.2 From an environmental perspective **Figure 5** highlights the constrained nature of the EISA. The Greater Wash Special Protection Area (SPA), Holderness Inshore and Holderness Offshore Marine Conservation Zones (MCZ) all occupy large areas between the array area and both the central and southern ECCs. At this stage preference was given to reducing overlap with designated sites where possible, though further interrogation was required to minimise overlap with hard constraints.

3.2 Description

3.2.1 Version 1 - Offshore ECC

3.2.1.1 The process of limiting route length, minimising crossing of cables/pipelines and avoiding obstacles principally enabled the development of three offshore ECC options. Version 1 Offshore ECCs were developed as straight-line options routeing west from the array area to three landfall zone

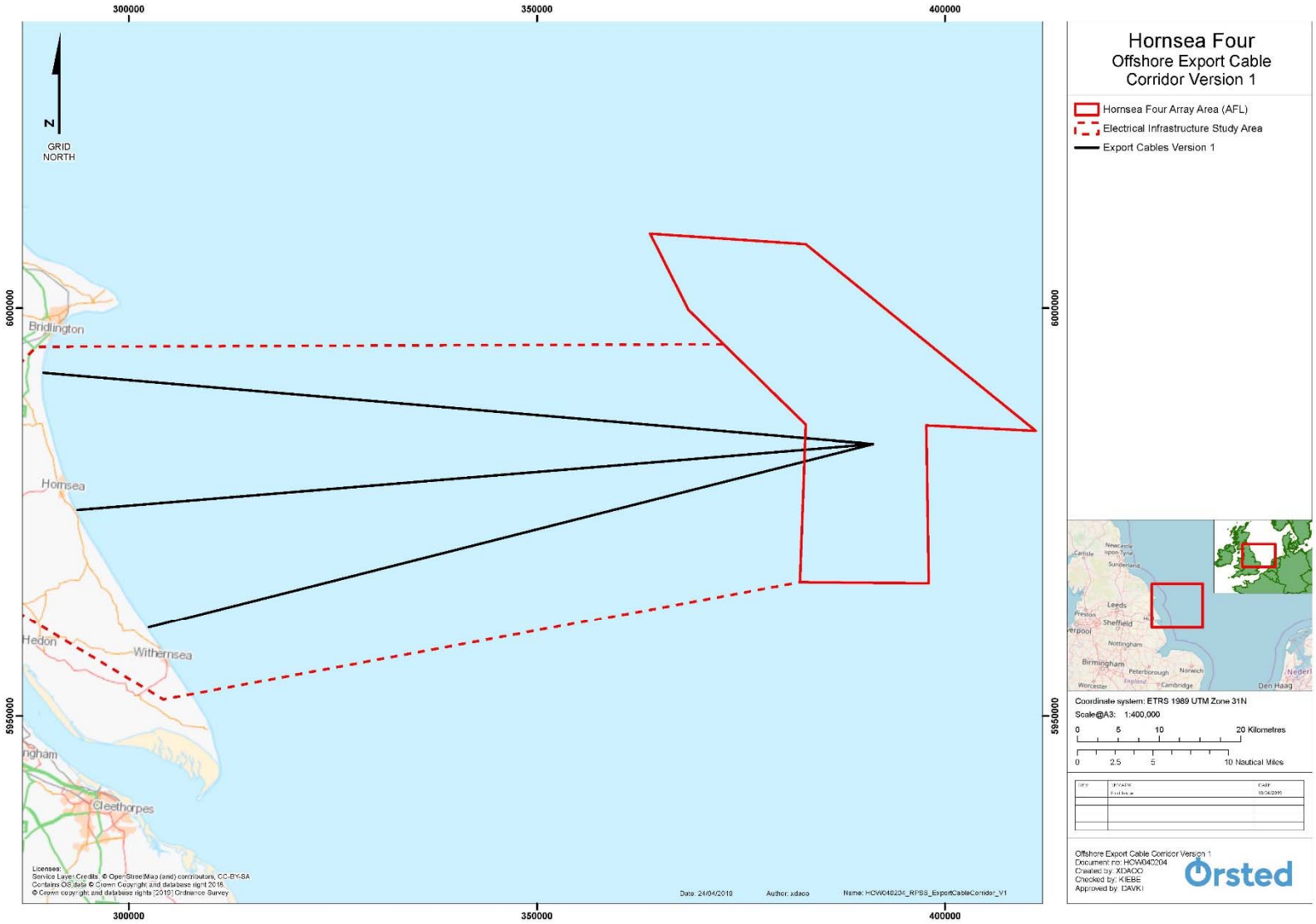

Figure 6. Hornsea Four Offshore Export Cable Corridor Version 1.

4 Refinement of Offshore ECC

4.1 Considerations

4.1.1.1 A number of potential ECC options were developed through a detailed engineering review, utilising the following principles:

- Avoid physical obstructions where possible;
- Minimise the number of turn points in the corridor;
- Aim to ensure that cables and pipelines are crossed at 90 degrees;
- Avoid conflicting seabed uses (e.g. oil and gas, aggregate areas);
- Avoid sites of nature conservation importance; and
- Apply appropriate buffers when routeing in close proximity or parallel to existing infrastructure (see Table 5).

Table 5. Route Refinement Buffer Distances

Asset Type	Status	Buffer Distance
Cables	Active/Proposed	250 m
	Inactive	100 m
Pipelines	Active/Proposed	500 m
	Inactive	250 m
Wrecks	Unprotected	50 m
	Protected	500 m
O&G Platforms	Active	500 m
	Inactive	500 m
Wellheads	All	100 m
Designated Sites for Nature Conservation	Not applicable	2 km
Wrecks	Not applicable	100 m
Navigational Aids	Not applicable	1 km
Shipping Lanes	Not applicable	100 m
Recreational Areas	Not applicable	100 m
Anchorage	Not applicable	100 m

4.2 Route Development

4.2.1.1 Building on Offshore ECC Version 1, Figure 7–Figure 9 present an overview of the ECC options (Version 2 – 4) developed in order to establish a Scoping Boundary (ECC Version 5) and subsequently refined further to a PEIR Boundary (ECC Version 6).

4.2.1.2 Each Offshore ECC option considered alternative ways of routing between the Array and Landfall sites, limiting interaction with constraints using the least amount of deviation possible. Where there were multiple options to avoid a particular constraint, the shortest option is chosen. Where uncertainty existed in relation to the optimum direction both

options were drawn-up for consideration. Refer to Table 10 which describes the alter-courses undertaken throughout the Offshore ECC route refinement process.

4.2.2 Version 2 - Offshore ECC

4.2.3 Refinement

4.2.3.1 Three Offshore ECC options were subject to engineering review and route optimisation (see Figure 7), aimed at satisfying the selection criteria i.e. minimising cable length, avoiding hard constraints and minimising overlap with existing seabed users.

4.2.4 Justification

4.2.4.1 The rationale for modifications to the offshore ECCs is summarised as follows:

- Maintain a perpendicular exit from landfall to the 15 m water depth contour;
- Avoiding physical constraints e.g. anchorages, dredging areas, dumping areas, wrecks, infrastructure, cables/pipelines, rocky ground, shallow banks; and
- Ensuring perpendicular crossings with existing and planned pipelines and cables.

4.2.4.2 Refer to Table 10 which describes the alter-courses undertaken throughout the Offshore ECC route refinement process and referenced in Figure 7.

4.2.5 Technical Review

4.2.5.1 Table 6 provides a high-level comparison between each of the three Offshore ECC options at Version 2, differentiating between what were considered to be defining factors in route preference (and therefore landfall zone selection). Two of the three Offshore ECC options at Version 2 routed through designated sites.

Table 6. Version 2 Offshore ECC Appraisal

	Defining Factors	
Offshore ECC Option	Physical Constraints	Environmental Constraints
Northern	- Length: 99km - Crosses 6 pipelines and 0 cables - Within 3500 m of a surface infrastructure point - Within 250 m of 3 wrecks - Within 1100 m of a well - Overlaps with Dogger Bank Creyke Beck Offshore Windfarm ECC	None

Middle	- Length: 98 km - Crosses 5 pipelines and 0 cables - Within 3500 m of a surface infrastructure point - Within 250 m of 2 wrecks - Within 120m of a well - Overlaps with Dogger Bank Creyke Beck Offshore Windfarm ECC	Within the Greater Wash SPA, Holderness Inshore and Holderness Offshore MCZs
Southern	- Length: 89 km - Crosses 6 pipelines and 0 cables - Within 1400 m of a surface infrastructure point - Within 250 m of 1 wreck - Within 150 m of a well - Overlaps with Dogger Bank Creyke Beck Offshore Windfarm ECC	Within the Greater Wash SPA, Holderness Inshore and Holderness Offshore MCZs

4.2.6 Environmental Review

4.2.6.1 The following environmental constraints were considered:

- Avoidance of known, charted wrecks

4.2.6.2 Routing to either of the southern offshore ECC route options results in interaction with several designated sites of nature conservation. Interaction with designated sites could be reduced through routing to the northern most ECC route option.

4.2.7 Commercial Review

4.2.7.1 The following commercial constraints were considered:

- Avoids a military firing range
- Avoids foul areas
- Aligns cable and pipeline crossings
- Avoids existing windfarm infrastructure
- Avoids oil and gas platforms

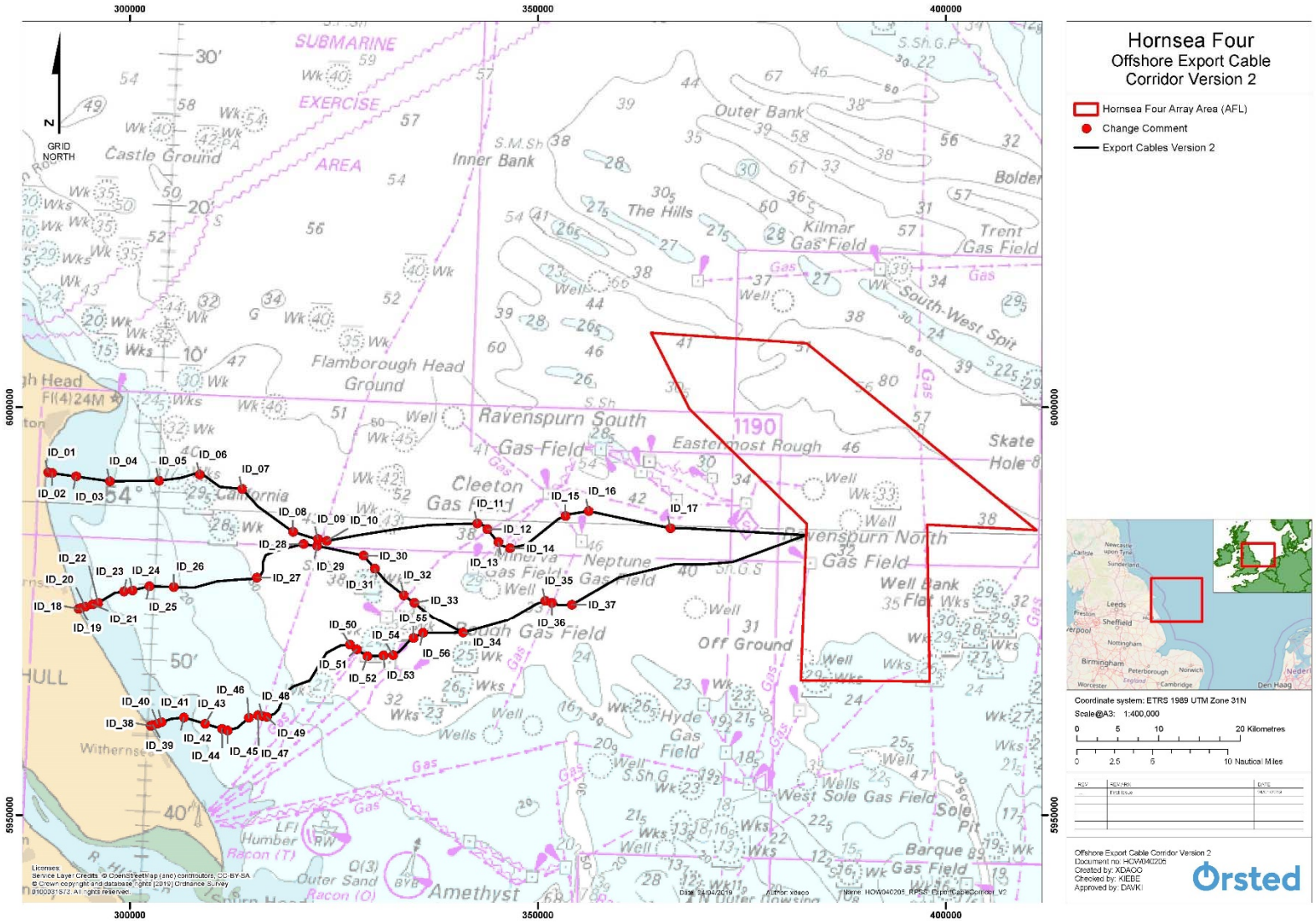

Figure 7. Hornsea Four Offshore Export Cable Corridor Version 2.

4.2.8 ECC Version 3

4.2.9 Refinement

4.2.9.1 A commitment to avoid the Holderness Coast Inshore and Offshore MCZs reduced the number of landfall options from 23 to seven, all within the northerly most landfall Zones A and B. Two alternative routes to the northern landfalls were created to avoid the MCZs.

4.2.9.2 Additional modifications were made offshore, to promote best possible crossing angles of other linear infrastructure and avoid wrecks as more historic environment data became available.

4.2.10 Justification

4.2.10.1 A commitment to avoid routing the Offshore ECC through marine designated sites, most notably the Holderness Coast MCZs, but also the Flamborough Head Special Area of Conservation (SAC) and Flamborough and Filey Coast Special Protection Area (SPA), meant the southernmost options were dropped from further consideration.

4.2.10.2 Refer to **Table 10** which describes the alter-courses undertaken throughout the Offshore ECC route refinement process and referenced in **Figure 8**.

4.2.11 Technical Review

4.2.11.1 Advised on preference to refine offshore cable and pipeline crossings to 90 degrees where possible.

4.2.12 Environmental Review

4.2.12.1 Advised on commitment to avoid routing through marine nature conservation designations and route around all known, charted maritime wreck sites.

4.2.13 Commercial Review

4.2.13.1 None at this stage.

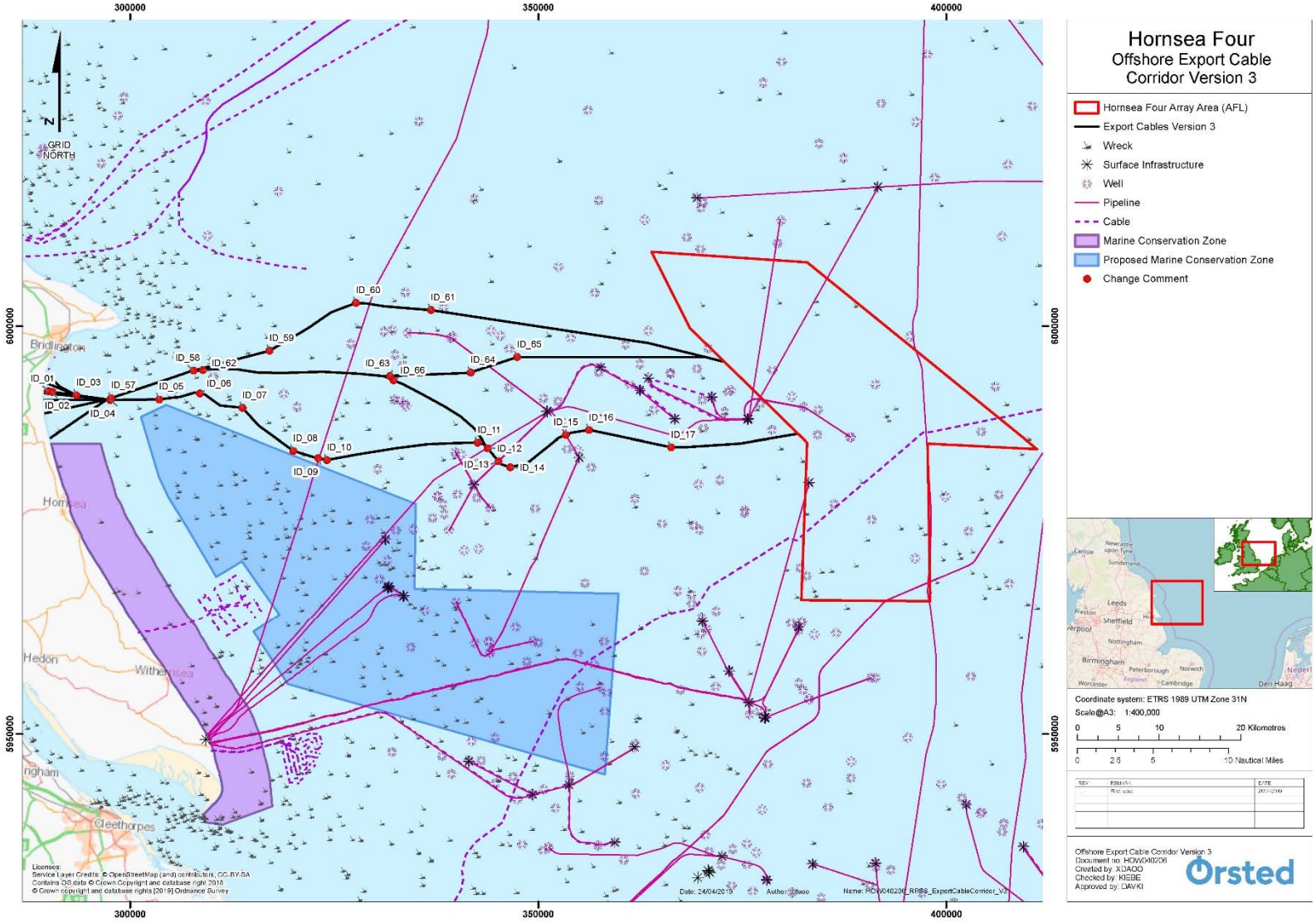

Figure 8. Hornsea Four Offshore Export Cable Corridor Version 3.

4.2.14 Version 4 – Offshore ECC

4.2.15 Refinement

4.2.15.1 Four potential Offshore ECCs were assessed against the refinement criteria and Routes 1 to 4 were subsequently modified as illustrated in **Figure 9**.

4.2.16 Justification

4.2.16.1 Modifications to increase the buffer distance between the MCZs, avoiding areas of hard substrate to the north of Route 1 and providing alternative crossing options for offshore pipelines and cables. The precise route of the Dogger Bank Offshore Windfarm cable was unknown at this stage, which increased the length of the required crossing.

4.2.16.2 Refer to **Table 10** which describes the alter-courses undertaken throughout the Offshore ECC route refinement process and referenced in **Figure 9**.

4.2.16.3 Version 4 Offshore ECC route options were categorised as follows:

- Route 1: Is the northernmost route, avoiding all major offshore infrastructure crossings and equating to 94 km in cable length. Sandwaves identified in the northern portion and some areas of hard substrate identified from BGS data. Potential Annex I sandbank habitats located in the nearshore area. One pipeline crossing is required.

- Route 2: Diverges from Route 1 adjacent to the array area, taking a more southerly path before re-joining route 1 approximately 20km from landfall and equates to 93 km in cable length. Two pipeline crossings is required.

- Route 3: Takes a more southerly route through more oil and gas infrastructure, joining Route 2 approximately halfway along its 95 km cable length. Four asset crossings appear to be coincidental with sandwaves, which may make sandwave clearance difficult at this location.

- Route 4: Follows Route 3 for the first half before diverging south to the southernmost landfall zones and is 95 km in cable length. Four asset crossings are present. This route is only 500m from the MCZ boundary and preference is therefore to relocate north.

4.2.17 Technical Review

4.2.17.1 Significant sandwaves were identified in the region of Route 1, potentially making installation technically challenging. Advised on preference to avoid major sandwaves and hard substrate to the north of Route 1.

4.2.18 Environmental Review

4.2.18.1 Advised preference to shift Route 4 northwards, increasing buffer distance from the MCZ boundary.

4.2.18.2 The project committed to the following:

- The Holderness Inshore Marine Conservation Zone (MCZ) (designated for Intertidal sand and muddy sand, Moderate energy circalittoral rock, High energy circalittoral rock, Subtidal coarse sediment, Subtidal mixed sediments, Subtidal sand, Subtidal mud, and Spurn head (subtidal)) will be avoided;
- The Holderness Offshore recommended MCZ (rMCZ) (proposed to be designated for North Sea Glacial Tunnel valleys, Subtidal coarse sediment, Subtidal sand, Subtidal mixed sediments and Ocean Quahog (*Arctica islandica*) will be avoided;
- The Offshore ECC will be routed to avoid all known wrecks with a buffer of 50m; and
- The Offshore ECC will be routed to avoid sandwaves and sandbanks as far as is feasibly possible.

4.2.19 Commercial Review

4.2.19.1 None at this stage.

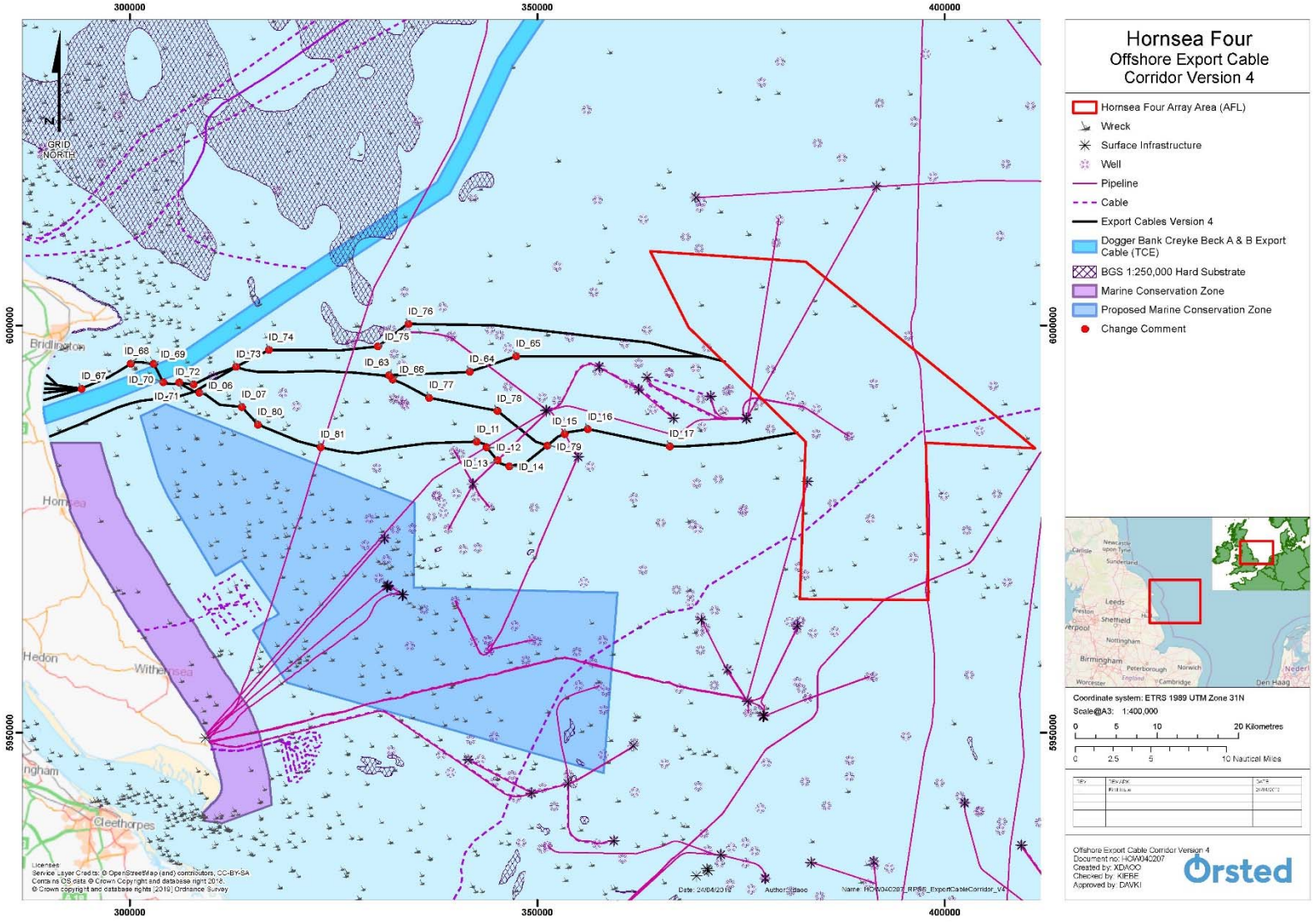

Figure 9. Hornsea Four Offshore Export Cable Corridor Version 4.

4.2.20 ECC Version 5

4.2.21 Refinement

4.2.21.1 Following a refinement assessment, Route 3 was identified as the preferred Offshore ECC option and formed the basis of Offshore ECC Version 5. This assessment involved the rating of each Offshore ECC option against a Black, Red, Amber and Green (BRAG) criteria, defined in Table 7.

Table 7: BRAG Rating

Rating	Summary
Black	Potential showstopper to development
Red	High potential to constrain development
Amber	Intermediate potential to constrain development
Green	Low potential to constrain development

4.2.21.2 Black and red constraints are critical in determining features that should be avoided wherever possible to avoid consenting risk, reduce EIA complexity and reduce the cost of mitigation. Amber and green constraints are those that may be more readily minimised or managed by employing appropriate mitigation measures.

4.2.21.3 The BRAG criteria assisted in the identification of key technical, consenting and commercial risks areas. Based on the BRAG appraisal, a detailed analysis was undertaken to reduce the number of Offshore ECC options from four down to one. A buffer was then applied to Offshore ECC Version 5, in order to create a Scoping Boundary of 3 km wide. This area provided a corridor within which there was a high degree of confidence that a viable ECC could be identified. It also contained sufficient limits of deviation to enable an iterative process (based on stakeholder feedback, further data acquisition and interrogation and, initial engineering optimisation work) for the evaluation of specific routes and infrastructure locations as Hornsea Four progressed through the pre-application phase.

4.2.21.4 The Scoping search area presented as Offshore ECC Version 5 is shown in Figure 10.

4.2.22 Justification

4.2.22.1 The BRAG assessment criteria are provided in Table 8 and appraisal in Table 9 below.

4.2.22.2 Route 3 was selected as the preferred option, as summarised below:

- Least interaction with sandwave features, meaning the lowest installation risk;
- Relatively low number of seabed obstructions;
- No interaction with MCZs or SACs;
- No interaction with CCS sites; and

- Not the highest commercial fisheries total landings.

4.2.22.3 The project was satisfied all reasonably foreseeable project options can could be accommodated in the final Scoping boundary, based on all known technical, commercial and environmental criteria, and the project Scoping boundary confirmed.

4.2.22.4 To maintain consistency with previous Orsted offshore windfarm projects, the following Scoping envelop was maintained:

- 3 km wide offshore ECC Scoping boundary
- Ambition to reduce this to a 1500 m corridor at PEIR and include a 500 m construction buffer either side for the final DCO application

4.2.22.5 These areas were consulted on between September 2018 (as part of the SoCC), October and November 2018 (Phase 1.A consultation with the public and formal Scoping of the project).

4.2.23 Technical Review

4.2.23.1 Undertook BRAG assessment – see **Table 9.**

4.2.24 Environmental Review

4.2.24.1 Undertook BRAG assessment – see **Table 9.**

4.2.25 Commercial Review

4.2.25.1 Undertook BRAG assessment – see **Table 9.**

Table 8. Offshore Export Cable Corridor Constraints Appraisal Criteria.

Constraint		Black	Red	Amber	Green
Technical	Geology	None	Hard strata.	Areas of very soft Holocene material and/or significant gravelly material.	Anything else
	Bathymetry	None	Water depth <10m	water depth <15m	water depth ≥15m
	Seabed Features	≥10 km of sandwave fields and/or ≥8 sandwave interactions.	Between 5–10 km of sandwave fields and/or ≤8 sandwave interactions.	Up to 5 km of sandwave fields and/or ≤5 sandwave interactions.	Limited distance of sandwave fields and/or ≤3 sandwave interactions.
	Seabed Slopes	>15° slope	≤10°–15° slope	≤5°–10° slope	≤5° slope
	Seabed Obstructions	Significant obstructions preventing installation.	Obstructions hampering installation.	Minor obstructions hampering installation.	No obstruction.
Environmental	Nature Conservation Sites	Intersects internationally or nationally protected habitats and species i.e. Marine Conservation Zones (MCZ), Special Areas of Conservation (SAC), Special Protection Areas (SPA), National Nature Reserves, Ramsar Sites, Sites of Specialist Scientific Interest (SSSI).	Within 2 km of an internationally or nationally protected habitat or species.	Within 1 km of an internationally or nationally protected habitats and species.	Beyond all internationally or nationally protected habitats and species.
	Archaeology	≤50 m of known wreck	≤100 m of known wreck	≤250 m of known wreck	≥250 m from known wreck

	Navigational Aids	≤500 m of aid	≤1000 m of aid	≤2000 m of aid	≥2000 m of aid
	Shipping Lanes	Intersects high volume shipping lane.	None	None	Avoids high volume shipping lane.
	Recreation	Intersects known recreation area.	None	None	Avoids known recreation area.
	Anchorages	≤500 m of anchorage.	≤1000 m of anchorage.	≤2000 m of anchorage.	≥2000 m of anchorage.
Commercial	Oil & Gas Infrastructure	None	≥5 crossings	3–5 crossings	≤2 crossings
	Electrical Export Cables	None	Agreement for crossing required.	Agreement for proximity required.	No proximity or crossing agreements required.
	Commercial Fisheries	None	Average ICES total value of landings (all gears, 2016) >3.2m GBP.	Average ICES total value of landings (all gears, 2016) 200k-3.2m GBP.	Average ICES total value of landings (all gears, 2016) <200k GBP.
	Carbon Capture & Storage	None	Obstructions hampering installation.	Minor obstructions hampering installation.	No obstruction.

Table 9. Offshore Export Cable Corridor BRAG Assessment.

Constraint		Route One	Route Two	Route Three	Route Four
Cable Length		103 km	102.5 km	106.5 km	107.5 km
Technical Review	Geology	6.2 km of muddy sandy gravel.	6.2 km of muddy sandy gravel.	6.4 km of muddy sandy gravel	6.4 km of muddy sandy gravel.
	Bathymetry	≥15 m depth	≥15 m depth	≥15 m depth	≥15 m depth
	Seabed Features	8 km sandwave field, interacts with 3 sandwaves.	10.1 km sandwave field, interacts with 3 sandwaves.	3.7 km sandwave field.	5 km sandwave field, interacts with 6 sandwaves.
	Seabed Slopes	≤5° slope	≤5° slope	≤5° slope	≤5° slope
	Seabed Obstructions	Relatively high obstruction density.	Low number of obstructions.	Low number of obstructions.	Medium density of obstructions with possible bite points.

Environmental Review	**Nature Conservation**	Offshore avoids the MCZ, SAC and SPA. Nearshore one landfall option crosses the SPA.	Offshore avoids the MCZ, SAC and SPA. Nearshore one landfall option crosses the SPA.	Offshore avoids the MCZ, SAC and SPA. Nearshore one landfall option crosses the SPA.	Offshore avoids the MCZ, SAC and SPA. Nearshore one landfall option crosses the SPA.
	Archaeology	Offshore avoids all known wreck sites. Nearshore one landfall within 100 m proximity to two wrecks and one within 250m.	Offshore avoids all known wreck sites. Nearshore one landfall within 100 m proximity to two wrecks and one within 250m.	Offshore avoids all known wreck sites. Nearshore one landfall within 100 m proximity to two wrecks and one within 250m.	Offshore avoids all known wreck sites. Nearshore one landfall within 100 m proximity to two wrecks and one within 250m.
	Navigational Aids	None identified.	None identified.	None identified.	None identified.
	Shipping Lanes	All routes equally affected.	All routes equally affected.	All routes equally affected.	All routes equally affected.
	Recreation	None identified.	None identified.	None identified.	None identified.
	Anchorages	None identified.	None identified.	None identified.	None identified.
Commercial Review	Oil & Gas Infrastructure	Avoids existing offshore infrastructure crossings.	Avoids existing offshore infrastructure crossings.	Avoids existing offshore infrastructure crossings though suspect future developments coming forward.	Avoids existing offshore infrastructure crossings though suspect future developments coming forward.
	Electrical Export Cables	All routes require one major crossing.	All routes require one major crossing.	All routes require one major crossing.	All routes require one major crossing.
	Commercial Fisheries	Average ICES total value of landings (all gears, 2016) 200k-3.2m GBP	Average ICES total value of landings (all gears, 2016) 200k-3.2m GBP	Average ICES total value of landings (all gears, 2016) 200k-3.2m GBP	Average ICES total value of landings (all gears, 2016) >3.2m GBP

	Carbon Capture & Storage	Proximity to White Rose CCS proposed project.		Proximity to White Rose CCS proposed project.		None identified.	None identified.

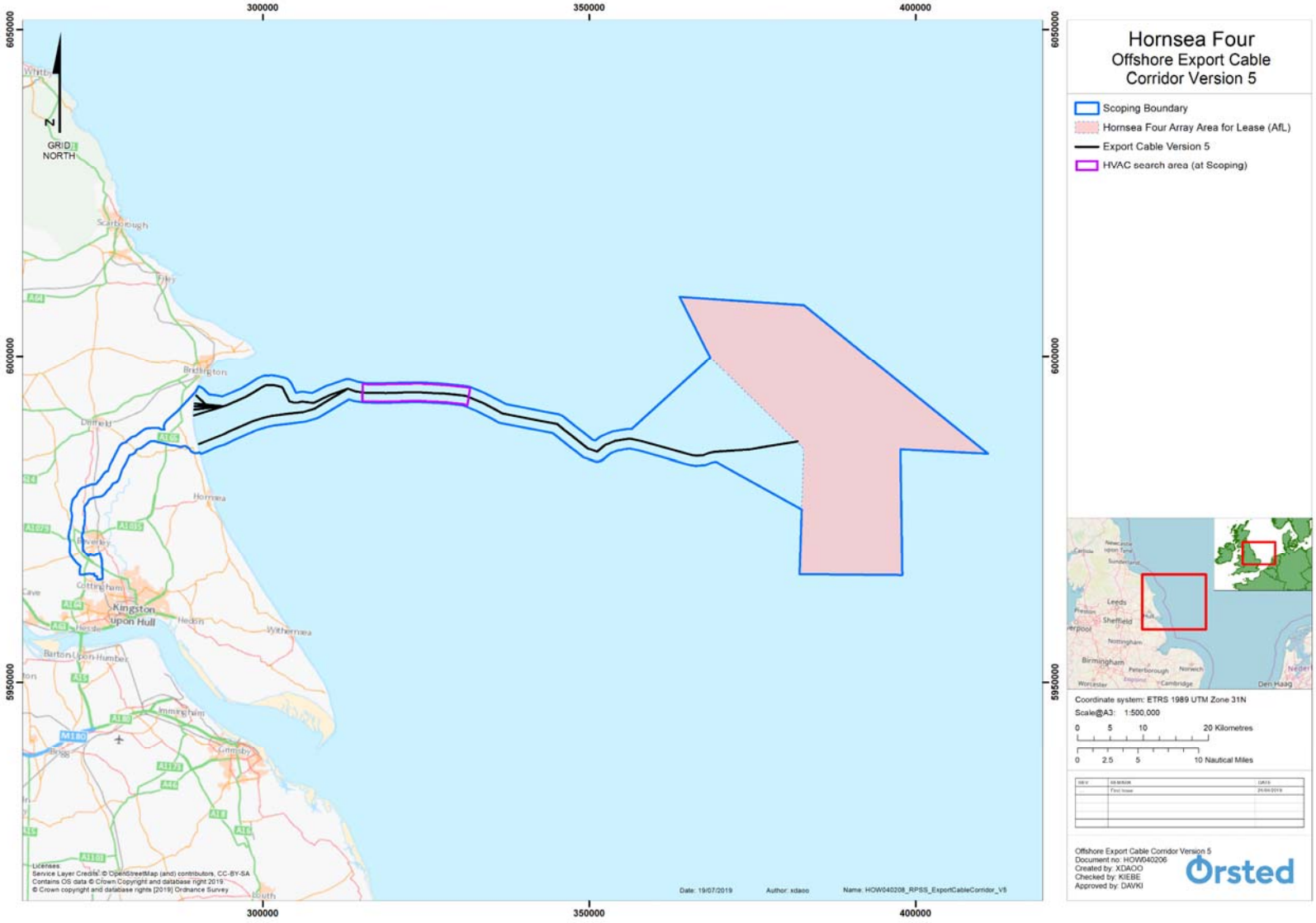

Figure 10. Hornsea Four Offshore Export Cable Corridor Version 5.

5 Selection of Preferred Offshore ECC and HVAC Booster Station Search Area

5.1 Introduction

5.1.1.1 The aim at this pre-PEIR stage was to establish a preferred Offshore ECC and HVAC booster station search area through the detailed assessment of technical, physical and environmental constraints to allow the Project sufficient confidence in order to commission site specific surveys.

5.1.1.2 The Offshore ECC corridor funnels out at the proposed landfall and at the offshore array area to allow flexibility as plans were further developed.

5.2 Offshore ECC

5.2.1 Considerations

5.2.1.1 In order to establish a preferred Offshore ECC boundary at the PEIR stage, the following principles were applied to the route refinement process on Offshore ECC Version 5:

- Minimise overlap with designated nature conservation sites;
- Minimise overlap with challenging ground conditions; and
- Minimise the number of cable/pipeline crossings and ensure they occur at as close to 90 degrees as possible.

5.2.2 Route Development

5.2.2.1 The precise Offshore ECC will continue to be further developed following receipt of further site-specific data. A marine survey is planned in order to acquire the data required for final route engineering. The objective of final route engineering is to finalise the offshore ECC based on conceptual ground modelling. This stage will use high-resolution geophysical and geotechnical data and the interpretation of this data to inform a conceptual ground model.

5.2.2.2 Based on the ground model, the offshore ECC may be deviated to further avoid obstacles (e.g. sand waves and chalk substrate), to follow sandwave troughs or to minimise remedial burial activities. Crossing angles may be deviated from perpendicular if scour potential can be minimised by doing so. Deviations and adjustments may also be made to reduce scour, to better fit the method of burial or to micro-route around features.

5.3 Offshore HVAC Booster Station

5.3.1 Identification of a Search Area

5.3.1.1 In electrical terms, the optimum position for a HVAC booster station along the export cable corridor is midway between the Offshore and Onshore Substation within the range of

45% to 55% of the total export distance, combining both on and offshore export cable lengths.

5.3.1.2 Hornsea Four requires up to three HVAC booster stations within this area, each a minimum separation of 100 m.

5.3.1.3 For the purpose of the HVAC booster station search area refinement process, layout may be in a grid, string or randomised. In order to establish a refined search area, the following key constraints were considered:

- Bathymetry
- Shipping
- Existing offshore infrastructure
- Nature conservation designated sites

5.3.1.4 At Scoping, a search area of 3 km wide and 16 km long (totalling 48 km^2 area), situated 25.3 km from shore was identified. At PEIR this is reduced by half to a corridor of 3 km wide and 8 km long (24 km^2 area) (**Figure 11**).

5.3.2 Technical Review

5.3.2.1 Bathymetry and seabed sediments are a development constraint where water depths are 50 m or greater and/or seabed sediments are characterised by exposed bedrock or heterogenous Quaternary till units with a high volume of boulders. The Hornsea Four search area is characterised by reasonably flat seabed conditions with water depths typically in the range of 50 m and so was largely deemed wholly developable.

5.3.3 Environmental Review

5.3.3.1 There are no nature conservation sites to constrain development of the HVAC Booster Station search area within proximity to the site.

5.3.4 Commercial Review

5.3.4.1 Shipping was a key human constraint to the refinement of the HVAC booster station search area. The available shipping information indicated that the western extent of the search area possesses an increased shipping intensity relative to other areas of the search area. While it should be noted that the shipping data was indicative, and did not constitute fixed shipping lanes, it was viewed as a constraint to avoid if possible.

5.3.4.2 Additionally, approximately 5 km inside the eastern boundary of the Scoping search area lies existing gas pipeline infrastructure, which transects the corridor.

5.3.5 Summary

5.3.5.1 A reduced 24 km^2 area was identified to the east of the Scoping HVAC booster station search area. This avoided the most challenging seabed conditions and highest density known shipping routes. This area was deemed to provide enough scope to maintain

flexibility in project design while addressing the key technical and consenting issues (Figure 11).

6 Refinement for PEIR Submission

6.1.1 Considerations

6.1.1.1 For the purposes of PEIR, the preferred offshore ECC was reduced down to 1.5 km wide (Figure 11) with a widening to 3 km at the offshore HVAC booster station search area.

6.1.1.2 A temporary working area of 500 m either side of the offshore ECC is incorporated into the 1.5 km offshore ECC, to ensure any vessels associated with the installation of the export cables and/or the offshore HVAC booster station can operate within close proximity to the offshore ECC boundary without risk of their anchors or jack-up legs being outwith the DCO order limits.

7 Refinement of Array Area

7.1.1.1 The Hornsea Four array area was 848 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate EIA, the project is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to consent application (DCO). This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR (Figure 11). The evolution of the AfL is detailed in the Site Selection and Consideration of Alternatives Chapter (A1.3) and this Annex. The final developable area taken forward to consent may differ from that presented in Figure 11 due to the results of the EIA, technical considerations and stakeholder feedback.

7.1.2 Technical Review

7.1.2.1 Bathymetry and seabed sediments could be a consideration where water depths are significantly greater than 60 m and/or seabed sediments are characterised by exposed bedrock or a high volume of boulders. The water depths vary from 25-62 m throughout the array, being shallowest in the southern part and deepest in the north-eastern part of the site. The deepest water depths, whilst less favourable for foundation installation, are technically feasible and therefore no water depth constraint was applied.

7.1.3 Environmental Review

7.1.3.1 There are no nature conservation sites which would directly constrain development of the array area within proximity to the site. However, baseline ornithological survey identified considerable ornithological interest within the array area, concentrated around the southernmost and northernmost areas of the site. In consultation with the statutory nature

conservation body and other relevant stakeholders, the project is proposing a reduced developable array area in order to reduce the potential for impacts on the visiting seabird population.

7.1.4 Commercial Review

7.1.4.1 Shipping will continue to be a consideration to the refinement of the array area as available shipping data indicates a number of shipping routes intersecting the site. Whilst existing data does not identify fixed shipping lanes, the data will be viewed as a consideration in future array area refinement and further consultation with shipping operators is planned.

7.1.4.2 A number of offshore infrastructure assets are located within proximity to the array area and will be considered through further consultation with asset owners / operators prior to DCO application.

7.1.4.3 The final array taken forwards is presented in **Figure 11**.

7.1.5 Conclusion

7.1.5.1 The Offshore ECC and associated HVAC booster station search area, presented in Version 6, has been derived through a combination of physical, commercial and environmental considerations balanced alongside engineering limitations. Decisions have been made by a multi-disciplinary team, taking into consideration consultation feedback as well as detailed studies.

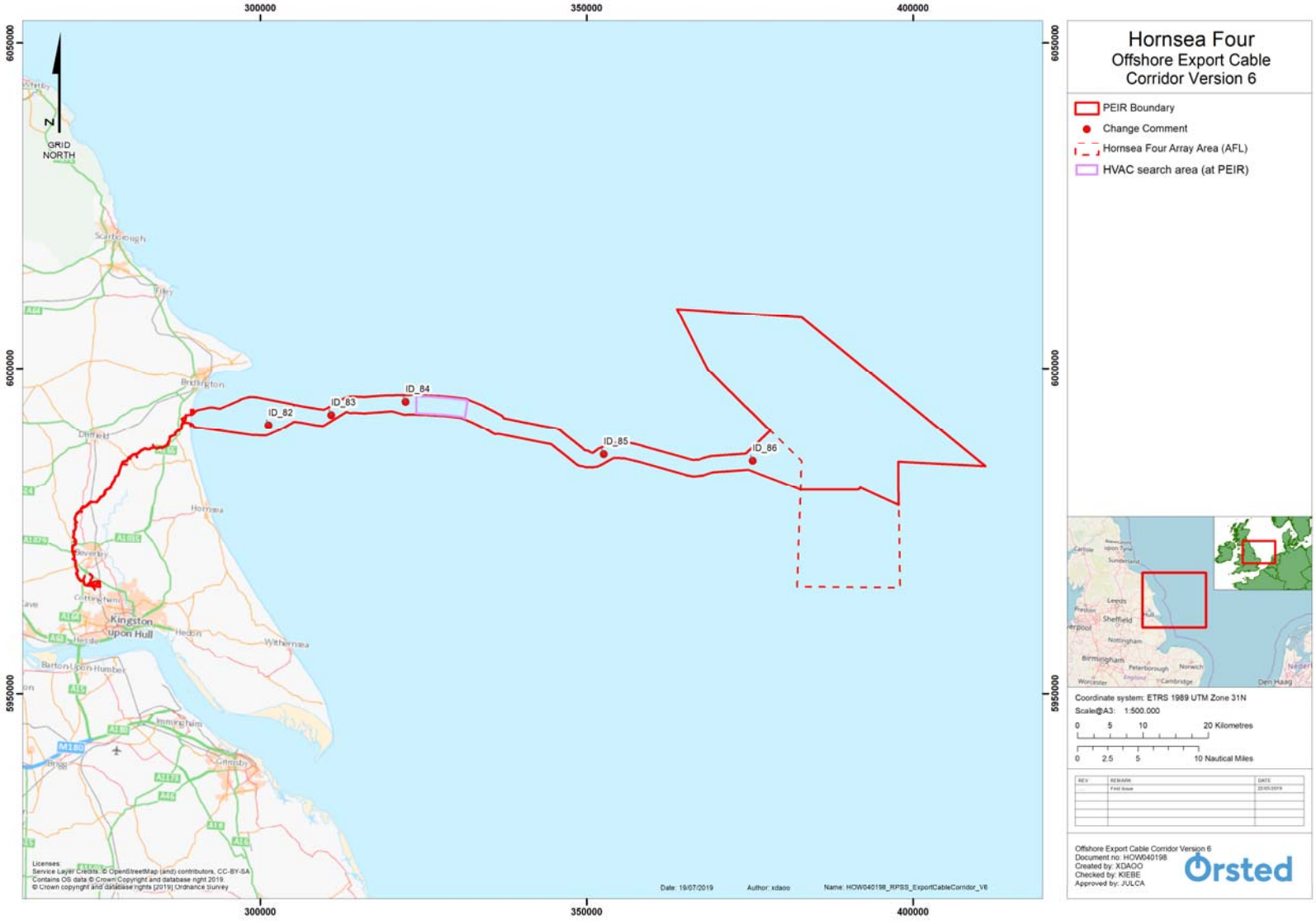

Figure 11. Hornsea Four Offshore Export Cable Corridor Version 6.

Table 10. Offshore Export Cable Corridor Alter-Courses.

Change ID	Reason for offshore ECC re-routing
ID_01	End of Intertidal Zone
ID_02	5m Depth Contour
ID_03	A disused spoil ground lies to the north marked by a west cardinal mark
ID_04	10m depth contour. Route is set to East
ID_05	CPA of the MCZ is 730m. Route set to EbN – Wreck avoidance
ID_06	Route varies EbN through SE to EbS – Wreck avoidance
ID_07	Route set to SE – Wreck and shoal avoidance
ID_08	CPA of the MCZ is 500m. Route set to ESE, aligning for crossing
ID_09	Pipeline crossing
ID_10	Route set to EbS
ID_11	Route set to SEbS – Aligning for crossings
ID_12	Pipeline Crossing
ID_13	Pipeline Crossing
ID_14	Route Set to NE – Aligning for crossing
ID_15	Pipeline crossing
ID_16	Route set to EbS. Paralleling pipeline
ID_17	CPA pipeline 1,400m. Route set to EbN. Heading for array area
ID_18	The beach is within a designated MCZ. A firing practice area lies to the north and a foul area to the south. From the beach, the route is set to NEbE
ID_19	The end of the intertidal zone
ID_20	The 5m depth contour
ID_21	CPA firing practice area extremity: 300m. CPA foul area: 1000m
ID_22	The 10m depth contour
ID_23	Route exits MCZ
ID_24	CPA foul area extremity: 700m
ID_25	Route set to E
ID_26	Route enters MCZ
ID_27	Route varies from E to N to ENE: Wreck and shoal avoidance
ID_28	Route set to EbS: aligning for crossing
ID_29	Pipeline Crossing, route exits MCZ
ID_30	Route set to SEbE. Aligning for crossing and crossing avoidance

ID_31	Route enters MCZ
ID_32	Pipeline crossing
ID_33	Route exits MCZ
ID_34	Route set to ENE (Links to bottom route)
ID_35	Route set to ESE. Aligning for crossing
ID_36	Pipeline crossing
ID_37	Route set to ENE. Heading for array area.
ID_38	The beach is within a designated MCZ. From the beach the route is set to ENE.
ID_39	End of intertidal zone.
ID_40	5m depth contour
ID_41	10m Depth contour
ID_42	Route set to ESE avoiding Westermost Rough wind farm.
ID_43	Route exits MCZ
ID_44	CPA Westermost Rough 730m
ID_45	Route set to ENE. Avoiding Westermost Rough and wrecks
ID_46	CPA Westermost Rough 1,100m
ID_47	Route set to E. Aligning for crossing. Route enters MCZ
ID_48	Pipeline crossing
ID_49	Route set to NE. Wreck avoidance
ID_50	Route set to SEbE. Aligning for crossings
ID_51	Pipeline crossing
ID_52	Route set to E. Passing between oil platform and wrecks.
ID_53	CPA oil platform 1600m
ID_54	Route set to NE, wreck avoidance.
ID_55	Route exits MCZ
ID_56	Route set to E, wreck avoidance.
ID_57	Route heads NE to stay away from MCZ.
ID_58	Route heads NE to avoid multiple crossings heading into the array. Avoids wrecks to N.
ID_59	Route heads NE, avoiding wrecks.
ID_60	Route heads E to line up for crossing.
ID_61	Route heads towards array, avoiding wrecks and wells.
ID_62	Route heads roughly E, ready to make crossing at correct angle.
ID_63	Route carries on E, staying away from wrecks, avoiding double asset crossing to SE

ID_64	Route heads NE to line up for pipeline crossing.
ID_65	Route heads E, heading for array.
ID_66	Route heads SE, heading for pipeline crossing
ID_67	Route fans out to approach all landfalls in zone A.
ID_68	Route bends to approach Creyke Beck A & B crossing at 90-degree angle.
ID_69	Route crosses Creyke Beck A & B cable corridor.
ID_70	Route bends away from Creyke Beck A & B towards array.
ID_71	Route splits to allow for different options heading to the array.
ID_72	Route bends NE to avoid having to make multiple crossings.
ID_73	Route heads ESE towards array, lining up for crossing.
ID_74	Route heads W, to avoid areas of hard substrate
ID_75	Route heads NE to avoid crossing.
ID_76	Route heads E towards array.
ID_77	Route heads ESE, creating alternative pipeline crossing location.
ID_78	Route heads SE, lining up for double asset crossing.
ID_79	Route bends NE heading for crossing.
ID_80	Route moved to north to keep as far away from the MCZ as possible.
ID_81	Pipeline crossing
ID_82	Crossing Creyke Beck A & B in shallower water. Avoiding wrecks surrounding former crossing location.
ID_83	Moved cable south to avoid P&A well
ID_84	Adjusted cable to line up for crossing of pipeline at 90 degrees.
ID_85	Ensuring crossing pipeline at 90 degrees
ID_86	Reduced funnel down to avoid having to make any additional pipeline crossings when approaching the array. Southern boundary of funnel moved to north of Babbage platform. Also avoiding large sandwaves in the northern part of the funnel.