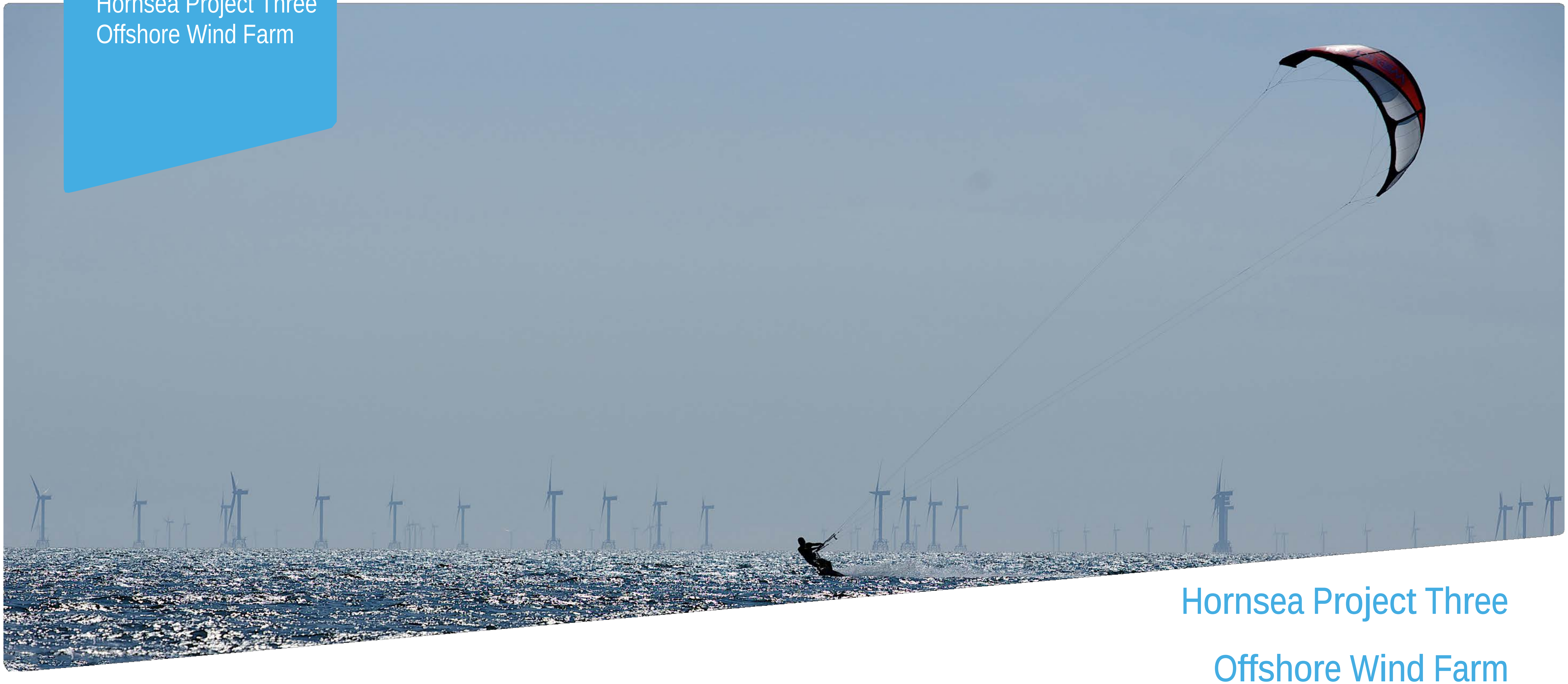
Hornsea Project Three
Offshore Wind Farm



# Hornsea Project Three

# Offshore Wind Farm

## Environmental Statement:
## Volume 4, Annex 4.2 – Selection and Refinement of the Offshore ECR and HVAC Booster Station

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Hornsea 3
Offshore Wind Farm

Ørsted

Environmental Impact Assessment

Environmental Statement

Volume 4

Annex 4.2 – Selection Refinement of the Offshore ECR and HVAC Booster Station

Report Number: A6.4.4.2

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## Acronyms

| Acronym | Description |
|---|---|
| AfL | Agreement for Lease |
| AIS | Automatic Identification System |
| cSAC | Candidate Special Area of Conservation |
| DCO | Development Consent Order |
| DDV | Drop Down Video |
| ECR | Export Cable Route |
| EIA | Environmental Impact Assessment |
| EWG | Expert Working Group |
| GIS | Geographical Information System |
| HVAC | High Voltage Alternating Current |
| IFCA | Inshore Fisheries and Conservation Authority |
| MCZ | Marine Conservation Zone |
| NNSSR | North Norfolk Sandbank and Saturn Reef |
| PEIR | Preliminary Environmental Information Report |
| PEXA | Practice and Exercise Areas |
| pSPA | Proposed Special Protection Area |
| SAC | Special Area of Conservation |
| SPA | Special Protection Area |
| TSS | Traffic Separation Systems |
| UK | United Kingdom |
| WNNC | Wash and North Norfolk Coast |

## Units

| Unit | Description |
|---|---|
| km | Kilometre (length) |
| kV | Kilovolts |
| m | Metre (length) |
| MW | Megawatts |

# 1. Introduction

## 1.1 Purpose of the Report

1.1.1.1 This annex supports volume 1, chapter 4: Site Selection and Alternatives of the Environmental Statement for the Hornsea Project Three Offshore Wind Farm (hereafter referred to as Hornsea Three). It documents the decision making behind the selection and refinement of the Offshore Export Cable Route (ECR) and High Voltage Alternating Current (HVAC) booster station locations (Stages 4-9).

1.1.1.2 This includes:

- Describing the high level environmental, physical and engineering constraints affecting the choice of options;
- Explaining the thought process behind the options considered at each stage of site selection;
- Comparing the performance of options to identify the least constrained locations for the Offshore ECR and HVAC booster station; and
- Demonstrating how the preferred routeing option has subsequently evolved taking account of responses during s42 and s47 consultation.

1.1.1.3 For further background information on project elements, site selection and alternatives this annex should be read in conjunction with the following documents:

- Volume 1, chapter 3: Project Description;
- Volume 1, chapter 4: Site Selection and Consideration of Alternatives;
- Volume 4, annex 4.1 – Grid Connection and Refinement of the Cable Landfall (Stages 3-4);
- Volume 4, annex 4.3 – Refinement of the Onshore Cable Corridor and Associated Infrastructure (Stages 5-7); and
- Volume 4, annex 4.4 – Post-Preliminary Environmental Information Report (PEIR) Changes (Stages 8-9).

## 1.2 Structure of the Report

1.2.1.1 Following this introduction (Section 1), the remainder of this report is structured as follows:

- Section 2 – describes the approach and methodology behind site selection including a summary of the siting principles and constraints considered;
- Section 3 – describes the baseline data used in appraising options;
- Section 4 – considers the initial selection of high level straight line ECR options to determine landfall selection;
- Section 5 – refines the ECR options to identify the project's offshore Scoping Boundary;
- Section 6 – defines a preferred ECR corridor and offshore HVAC booster station location;
- Section 7 – describes the routeing refinements considered for PEIR submission and consultation; and
- Section 8 – describes how the preferred ECR corridor evolved following further review of consultation responses and Environmental Impact Assessment (EIA) Studies and how the offshore HVAC Booster Station Search Area was refined.

# 2. Site Selection Methodology

## 2.1 Introduction

2.1.1.1 At a high level, offshore cable routing is a minimisation exercise to find the shortest route from the offshore Agreement for Lease (AfL) to a chosen landfall site under constraints dictated by engineering limitations, physical, third party and environmental constraints and seabed use.

2.1.1.2 The aim of the process was to establish indicative routes for the offshore ECR that could be developed through a staged approach to identify a route that Hornsea Three had sufficient confidence in to commission site specific surveys on. A preferred ECR could then be taken through the EIA process, whilst retaining sufficient flexibility to enable refinement following receipt of the survey outputs and stakeholder feedback during consultation.

## 2.2 Study Area

2.2.1.1 A Study Area was defined (see Figure 2.1) primarily by the Hornsea Three AfL and straight line Offshore ECR options from the array area to landfall. This Study Area took account of the high levels of existing infrastructure and assets that may need to be crossed in the vicinity of the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC) by incorporating a slight increase in width in this area on the west of the Study Area. This was considered necessary to allow some additional space for potential route deviations to ensure appropriate crossing angles could be achieved during final route design. .At the southern, landfall end of the route, the Study Area splayed to cover a range of landfall options whilst landfall refinement work was still ongoing. It was established that ECR options should fall within this Study Area.

## 2.3 Staged Approach

2.3.1.1 The Offshore ECR options were developed and refined following a staged approach which involved:

- Stage 1 – Identification of the former Hornsea Zone;
- Stage 2 – Identification of Hornsea Three Array area within the former Hornsea Zone;
- Stage 3 – Identification of grid connection location and initial level landfall appraisal;
- Stage 4 – Identifying potential offshore ECR corridor options through the high-level screening of physical constraints to help inform the selection of coastal landfall;
- Stage 5 – Refining offshore ECR corridor options to identify the project's Scoping Boundary;
- Stage 6 – Defining a preferred ECR and booster station location through the detailed assessment of physical constraints;
- Stage 7 – Refining the offshore ECR to establish a preferred route for PEIR, s42 and s47 Consultation;
- Stage 8 – Refining the preferred route following further review of consultation responses and EIA Studies; and
- Stage 9 – Confirming the final preferred option(s) as part of the Development Consent Order (DCO) application.

## 2.4 Engineering Limitations

2.4.1.1 The following considerations were general principles used by engineers from Stage 5 onwards in the site selection process in order to determine appropriate route options.

*Bathymetry and Slopes*

2.4.1.2 Figure 2.2 provides detail of bathymetric features within the Study Area. The larger sandbanks associated with various SACs are considered to pose potential technical constraints and were avoided if possible.

*Turns and Lay Radii*

2.4.1.3 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.

*Landfall Approach*

2.4.1.4 To minimise the complexity of cable installation at the landfall, the angle of the cable at shore approach is chosen to find a compromise between the following parameters:

- Minimisation of the shore pull length across the landfall area to minimise the maximum pull load on the cables;
- Maximise the distance from the coast of the first turn to simplify marine operations nearshore whilst reaching deeper water depths as quickly as possible; and
- Be as perpendicular as possible to nearshore wave effects to ease installation and minimise the loads on any exposed part of the cable.

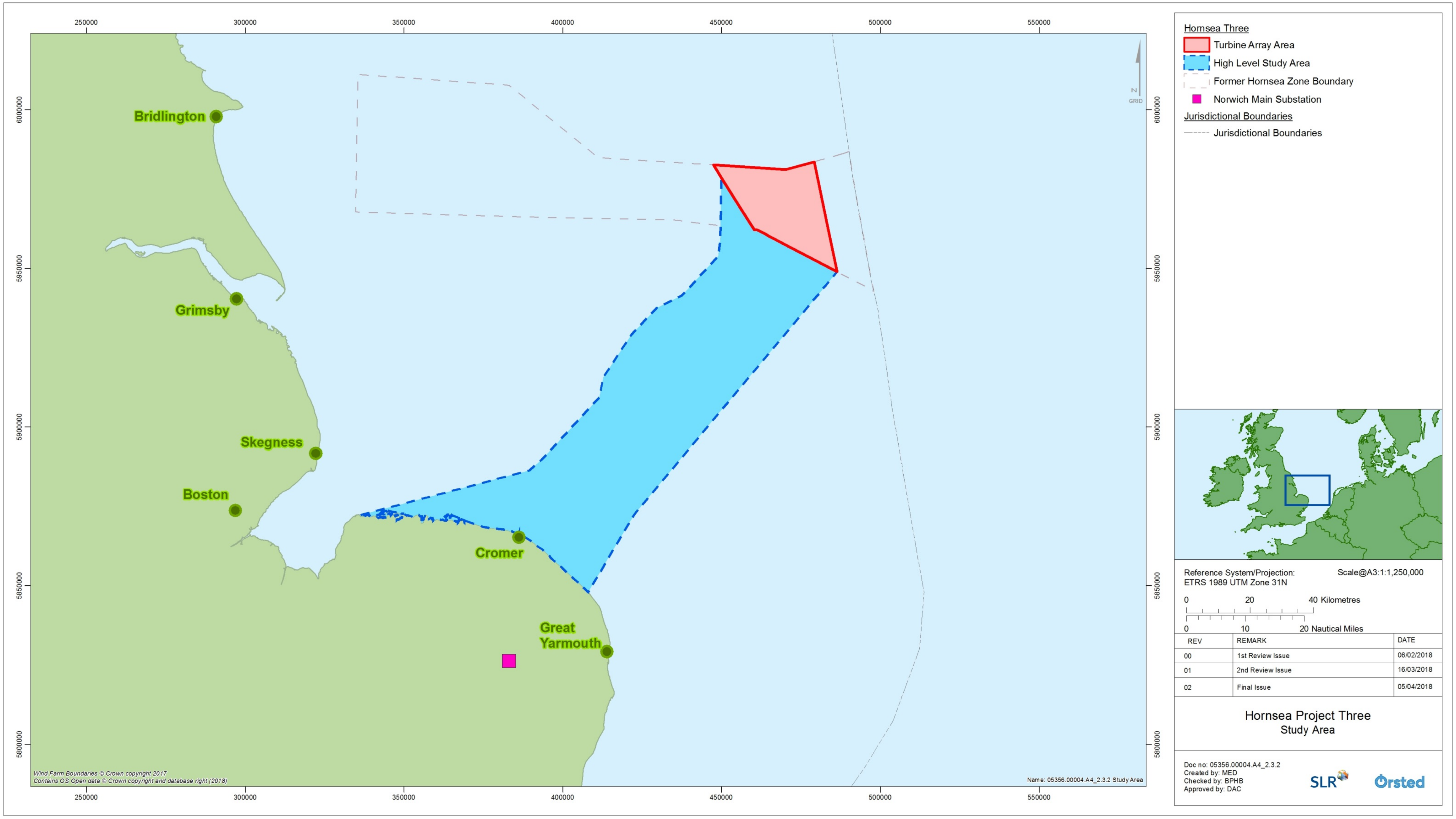


Figure 2.1: Study area.

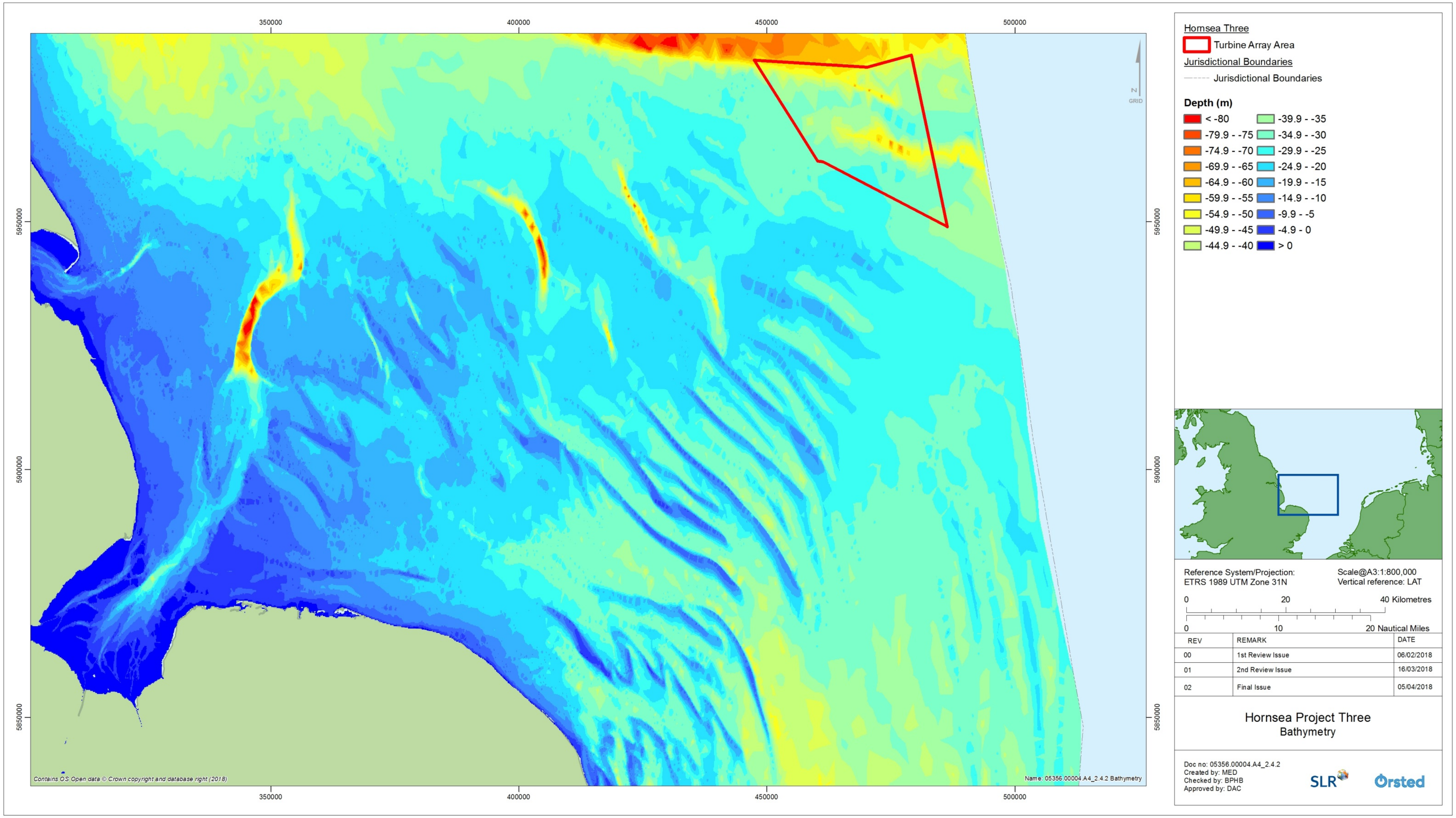


Figure 2.2: Bathymetry.

# 3. Baseline Data

## 3.1 Introduction

3.1.1.1 This section introduces the various engineering limitations and constraints considered within the site selection process. Seeking to minimise interaction with physical constraints such as cables and pipelines played a key part in establishing indicative ECR corridor options within Stage 4. These options were then refined further within Stage 5, taking account of obstructions such as surface and subsurface infrastructure as well as aggregate areas. Stage 6 refined the options further still, taking account of more detailed environmental information such as sandbank features and chalk beds. Stage 7 saw limited refinement in the form of a temporary working area with Stage 8 seeing further refinement taking on board statutory consultee responses from s42 and s47 consultation. Stage 9 presents the final offshore ECR and associated infrastructure application boundary for the Hornsea Three DCO application.

## 3.2 Constraints

3.2.1.1 Figure 3.1 provides an overview of the Geographical Information System (GIS) data collected within the Study Area.

### 3.2.2 Physical and Third Party

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

3.2.2.2 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 third party 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.

3.2.2.3 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.

3.2.2.4 Table 3.1 presents the physical and third party constraints considered along with a preference of mitigation.

Table 3.1: Physical and Third Party Constraints.

| Constraint | Preference | Mitigation |
|---|---|---|
| Ground Conditions (Rock/Chalk) | Avoid | Correct tool selection, reduced burial or use of cable protection |
| Wrecks (Protected) | Avoid | No mitigation, avoid through route selection and micrositing |
| Navigation Aids | Avoid | No mitigation, avoid through route selection and micrositing |
| Anchorage Areas | Avoid if possible | Re-route, move anchorage site, deep burial |
| Cables (Crossing) | Avoid if possible. Seek to cross at an angle of 90 degrees and where not possible, minimise number. | Re-routing, crossing agreement with associated measures |
| Cables (Proximity) | Avoid if possible. Seek to avoid paralleling for long stretches. | Re-routing, proximity agreement with associated measures |
| Pipelines (Crossing) | Avoid if possible. Seek to cross at an angle of 90 degrees and where not possible, minimise number. | Re-routing, crossing agreement with associated measures |
| Pipelines (Proximity) | Avoid if possible. Seek to avoid paralleling for long stretches. | Re-routing, proximity agreement with associated measures |
| Excessive Slopes | Avoid if possible as may prevent successful burial. | Correct cable burial tool selection, dredging, re- routing |
| Shallow Water | Avoid if possible | Vessel selection or rerouting |
| Depressions | Avoid if possible | Correct cable burial tool selection, reduced burial or re-routing |
| Seabed Mobility | Avoid if possible | Correct cable burial tool selection, dredging, re- routing |
| Sandwaves, Megaripples etc. | Avoid if possible | Correct cable burial tool selection, dredging, re- routing |
| Planned Developments (Cables and Pipelines) | Manageable | Stakeholder engagement |
| Export Cable Paralleling | Manageable | Route Planning |

### 3.2.3 Seabed Use

3.2.3.1 Areas exploited by human activities that could increase both the risk to the cable during operation and be a source of conflict during installation were considered in route development. Generally these areas should be avoided (for example, Bacton Gas Terminal's offshore storage area and its associated Bacton to Walcott Sandscaping Scheme), although in certain instances, such as shipping routes and fishing grounds, conflicts could be appropriately managed.

3.2.3.2 Table 3.2 presents the seabed use constraints considered along with a preference of mitigation.

Table 3.2: Seabed Use Constraints.

| Constraint | Preference | Mitigation |
|---|---|---|
| Offshore Infrastructure (Carbon Capture, Gas Storage etc.) (excludes cables and pipelines which are addressed in Table 1). | Avoid/maintain separation distance | Re-routing, proximity agreement with associated measures |
| Aggregate Areas | Avoid | No mitigation, avoid through route selection and micrositing |
| Military Practice and Exercise Areas (PEXA) | Avoid | No mitigation, avoid through route selection and micrositing |
| Dredging Areas | Avoid | Re-route, deep burial |
| Dumping Grounds (Military) | Avoid | No mitigation, avoid through route selection and micrositing |
| Dumping Grounds (General) | Avoid if possible | Re-route, dredging |
| Traffic Separation Systems (TSS) | Manageable | Notice to mariners, VHF broadcasts |
| Shipping routes | Manageable | Notice to mariners, VHF broadcasts |
| Fishing Grounds | Manageable | Re-route, deep burial |

### 3.2.4 Environmental

3.2.4.1 There are a range of European and nationally protected sites within the Study Area. However, due to the fact that appropriate technology and alternative methods of construction can in some cases mitigate or minimise impact upon environmentally sensitive areas, designations were not viewed as a defining factor in the early stages of route selection. However as discussed later within this Annex, some modifications to routeing were undertaken to avoid specific parts of specific designated areas.

3.2.4.2 Table 3.3 presents the environmental constraints considered along with a preference of mitigation.

Table 3.3: Environmental Constraints.

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

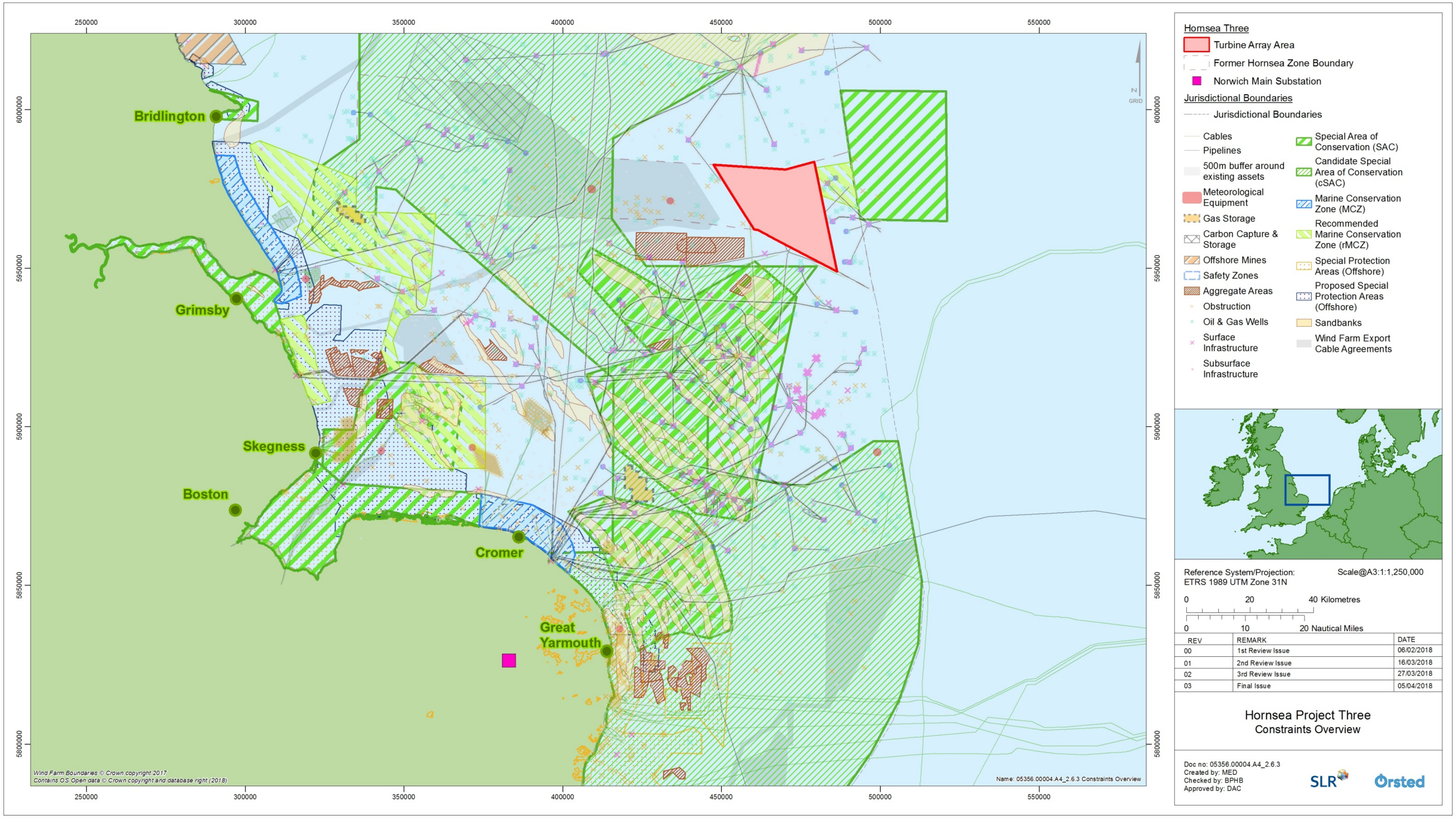


Figure 3.1: Constraints overview.

# 4. Stage 4 – Initial Selection of Offshore ECR Options

## 4.1 Considerations

4.1.1.1 Having refined the number of candidate landfall zones down to two options (See Annex 4.1 for further information), five potential offshore ECR corridor options were established through the high-level screening of physical constraints in order to interrogate whether landfall zones 2 and 4 were feasible from an offshore connection perspective.

4.1.1.2 From an environmental perspective, Figure 3.1 highlights the constrained nature of the Study Area. The North Norfolk Coast Special Protection Area (SPA), Greater Wash proposed Special Protection Area (pSPA), and North Norfolk Sandbank and Saturn Reef (NNSSR) SAC all span large areas between the array area and both landfall zones. Due to the position of the array area and the AfL, avoiding these designations entirely (by substantially increasing the ECR length) was considered to be economically less preferable and technically more challenging. Given that complete avoidance of these sites was an unrealistic target at this stage of route selection, they were not therefore considered to be a defining factor in landfall zone selection. Notwithstanding this, the presence of smaller extents of sensitive areas, notably the Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) and Haisborough, Hammond and Winterton SAC, did help to differentiate between ECR corridors and therefore influence the routes in the immediate foreshores of the two landfall zones. At this stage preference was given to reducing overlap of European designated sites (SAC) over nationally designated sites (MCZ).

4.1.1.3 The defining factors for the purposes of landfall zone selection, from an offshore ECR perspective, were considered to be the ability of the ECR corridor to avoid or minimise interactions with hard constraints (physical obstacles) within the Study Area. Figure 4.1 and Figure 4.2 provide an overview of five simplified offshore ECR options with environmental and infrastructure constraints respectively.

## 4.2 Description

4.2.1.1 The process of limiting route length, minimising crossing of cables/pipelines and avoiding obstacles enabled the development of five offshore ECR options. ECR 1 was developed as an initial straight line option routeing south west from the array area to landfall 2. ECR 2 took a similar straight line approach before deviating south to landfall zone 4. While ECR 3 also terminated at landfall zone 4, it took an altogether different approach by routeing south initially to navigate hard constraints before aligning south west to also terminate at landfall zone 4. Two further options, ECR 4 and 5 were established taking a more convoluted path between hard constraints to make landfall at zone 2.

## 4.3 Comparison

4.3.1.1 Table 4.1 provides a high level comparison between each of the offshore ECR corridor options, differentiating between what were considered to be defining factors in route preference (and therefore landfall zone selection). All ECR corridor options route within the NNSSR SAC, Greater Wash pSPA and Southern North Sea candidate Special Area of Conservation (cSAC) and those considerations that were seen to be common across all options are therefore are not included in this table.

## 4.4 Summary

4.4.1.1 Both landfall zones 2 and 4 possessed viable onshore connections (as identified in annex 4.1). However, with the complexities surrounding Bacton Gas Terminal, both in terms of the number of cable/pipeline crossings required close to shore, and the proposed Bacton to Walcott Sandscaping Scheme associated with the Coastal Management Scheme, obtaining landfall at zone 4 was seen as a significantly greater challenge both technically and commercially. While it is acknowledged that various wind farm ECR corridors have the potential to impact upon landfall zone 2, they do not create such a pinch point of physical constraints to make this unviable. As such, there was clear evidence to support a preference for proceeding with an offshore ECR connecting to landfall zone 2.

4.4.1.2 Of the three ECR options routeing to landfall zone 2, while ECR 1 would appear to interact with a greater number of hard constraints, it was determined that as the shortest, simplest indicative route proposed, it was the most flexible in terms of capacity for further refinement and should be taken forward to Stage 5 in order to establish a Scoping Corridor.

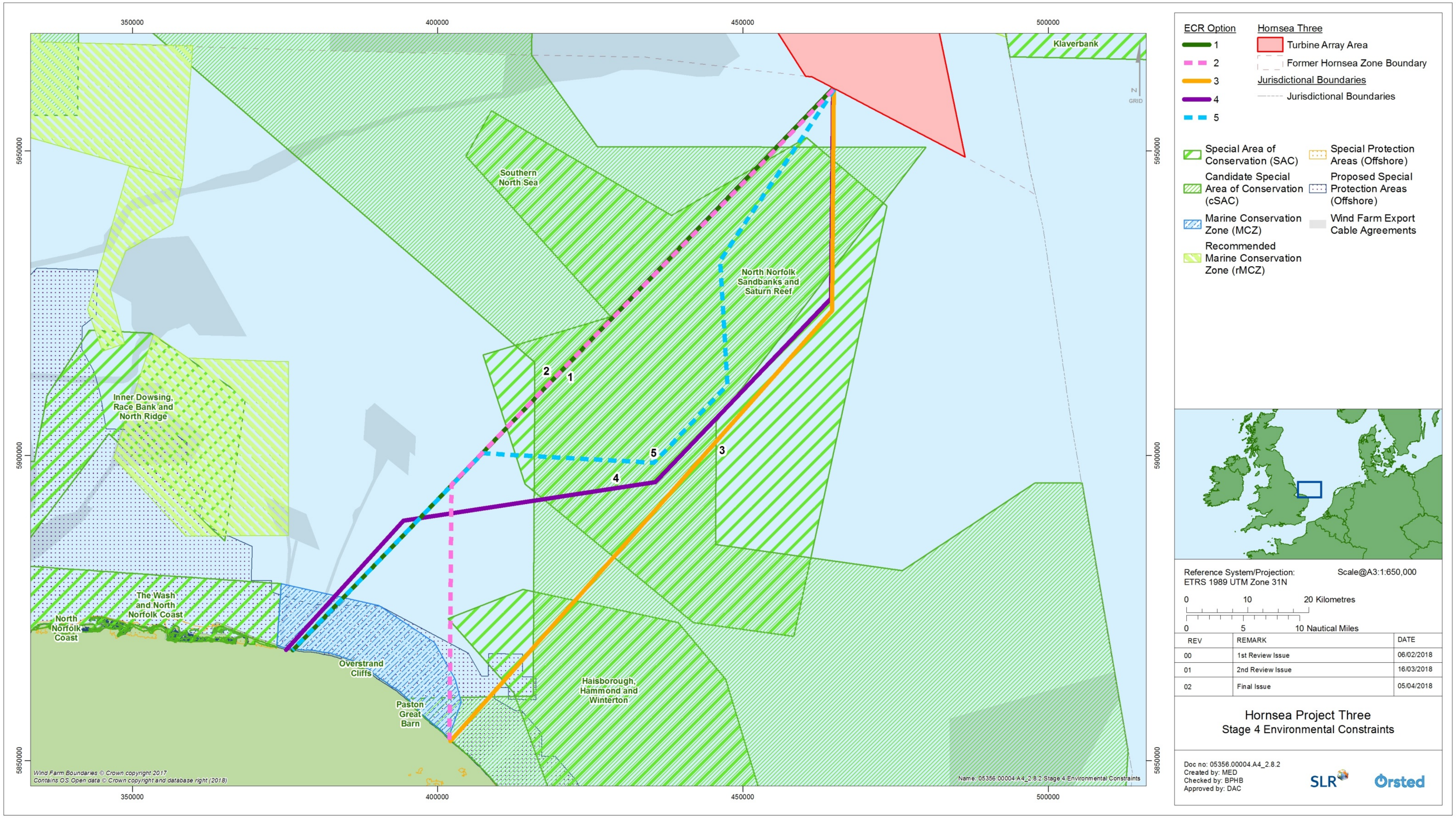


Figure 4.1: Stage 4 - Environmental constraints.


Figure 4.2: Stage 4 - Infrastructure constraints.

Table 4.1: Stage 4 – Comparison of ECR Corridor Options.

| ECR Ref. | Landfall Zone | Defining Factors | |
|---|---|---|---|
| | | Physical | Environmental |
| 1 (green) | 2 | - Length:128 km<br>- Crosses 13 pipelines and 5 cables<br>- Within 500 m of 1 surface infrastructure point<br>- Within 500 m of 4 wrecks<br>- Within 500 m of 1 well<br>- Conflicts with Sheringham Shoal and Dudgeon offshore wind farm ECR corridors | - Within Cromer Shoal Chalk Beds MCZ |
| 2 (pink) | 4 | - Length: 132 km<br>- Crosses 20 pipelines and 6 cables Within 500m of 3 obstructions<br>- Within 500m of 1 surface infrastructure point<br>- Within 500m of 7 wrecks<br>- Within 50m of 1 well; within 500m of 1 wells<br>- Conflict with Bacton Gas Terminal ECR and proposed Bacton to Walcott Sandscaping Scheme | - Within Haisborough, Hammond and Winterton SAC<br>- Within Cromer Shoal Chalk Beds MCZ |
| 3 (orange) | 4 | - Length: 131 km<br>- Crosses 15 pipelines and 3 cables<br>- Within 500 m of 3 obstructions<br>- Within 500 m of 1 subsurface infrastructure point<br>- Safety zone<br>- Within 500 m of 11 wrecks<br>- Within 50 m of 2 wells; within 500m of 5 wells<br>- Conflict with Bacton Gas Terminal ECR and proposed Bacton to Walcott Sandscaping Scheme | - Within Haisborough, Hammond and Winterton SAC |
| 4 (purple) | 2 | - Length: 146 km<br>- Crosses 7 pipelines and 5 cables<br>- Within 500m of 1 obstruction<br>- Within 500m of 2 surface infrastructure points<br>- Within 500m of 8 wrecks<br>- 2 safety zones<br>- Within 50m of 1 well; within 500m of 6 wells<br>- Conflicts with Sheringham Shoal and Dudgeon offshore wind farm ECR corridors | - Within Cromer Shoal Chalk Beds MCZ |
| 5 (blue) | 2 | - Length: 145 km<br>- Crosses 9 pipelines and 6 cables<br>- Within 500m of 2 obstructions<br>- Within 500m of 4 wrecks<br>- Within 500m of 1 well<br>- Conflicts with Sheringham Shoal and Dudgeon offshore wind farm ECR corridors | - Within Cromer Shoal Chalk Beds MCZ |

# 5. Stage 5 – Refinement of Offshore ECR Options

## 5.1 Considerations

5.1.1.1 Stage 5 saw the identification of a number of potential ECR corridor options which 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 were crossed as close to 90 degrees as possible for technical reasons;
- Avoid conflicting sea bed uses (e.g. oil and gas storage areas, aggregate areas etc.); and
- Apply a 50 m buffer when routeing in close proximity or parallel to existing linear infrastructure to ensure cable integrity.

## 5.2 Route Development

5.2.1.1 Figure 5.1 presents an overview of the various ECR corridor options that were developed in order to establish a Scoping Boundary with Figure 5.2 to Figure 5.5 providing a detailed view of the routeing constraints.

5.2.1.2 Each option was established by considering alternative ways of getting between the Array area and landfall, limiting the amount of interaction with constraints using the least amount of deviation possible.

5.2.1.3 Where there were multiple options for turning to avoid a particular constraint, the shortest option was chosen. Where uncertainty existed in relation to the optimum direction (i,e. choosing a longer ECR option with less interaction with constraints, or vice versa) both ECR options were drawn up for consideration.

5.2.1.4 A buffer was then applied to the ECR corridor options to create a broad Scoping Boundary of approximately 10 km in width.

5.2.1.5 This area provided a corridor within which there was a high degree of confidence that a viable corridor 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 the Project progressed through the pre-application phase. The Scoping search area is shown on Figure 5.6 below.

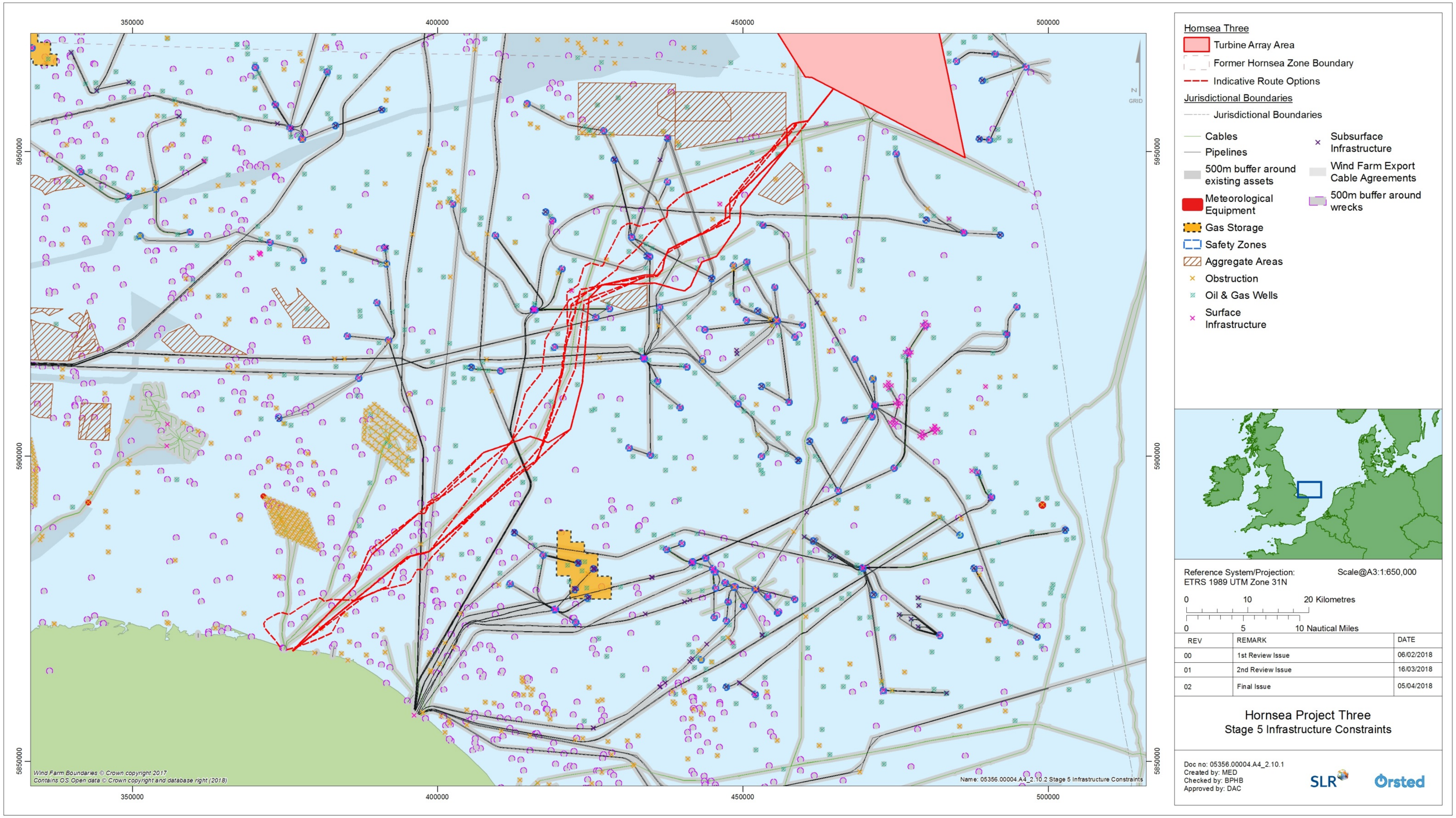


Figure 5.1: Stage 5 – ECR offshore corridor options (Infrastructure constraints).

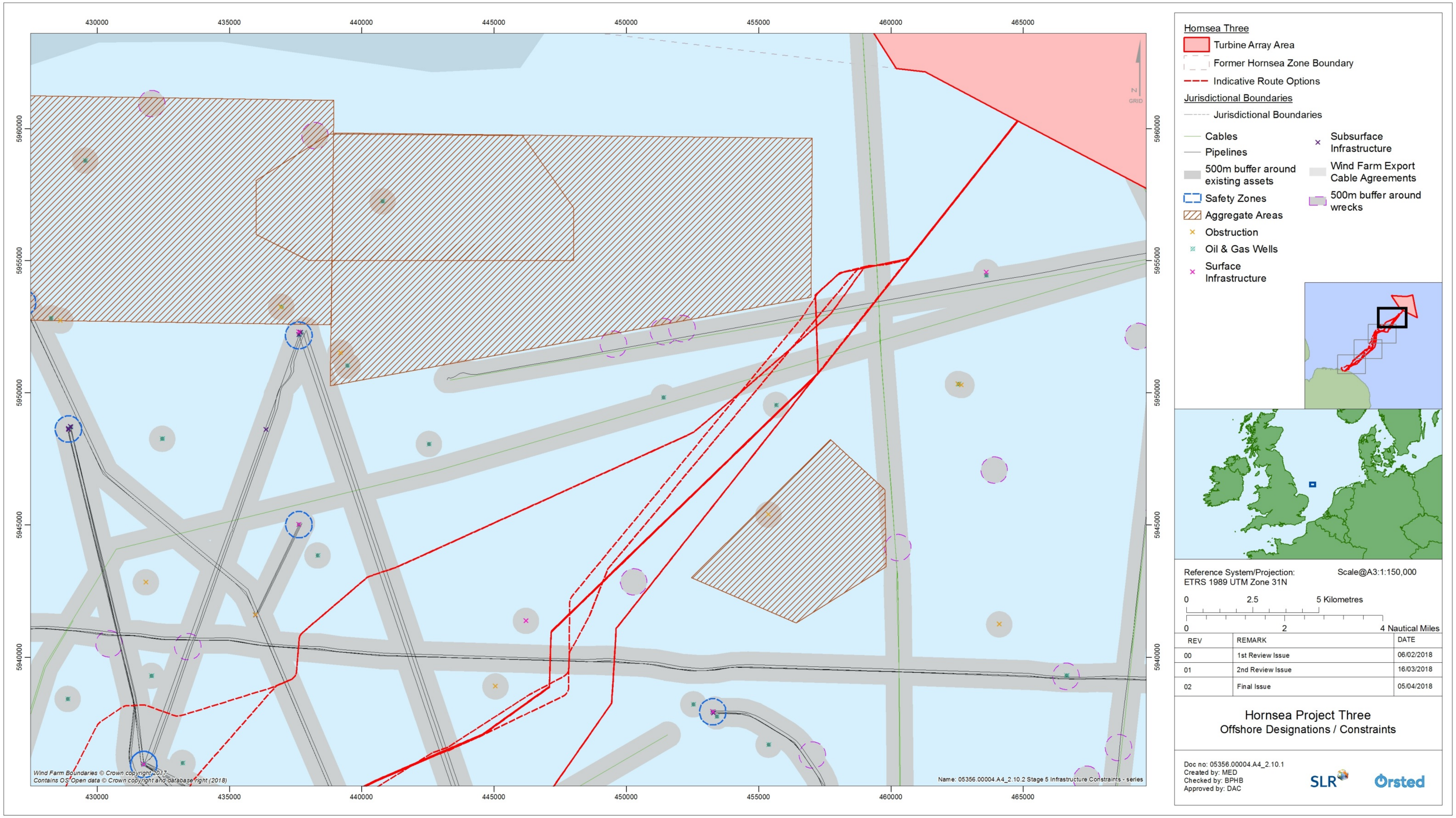


Figure 5.2: Stage 5 – ECR offshore corridor options (Infrastructure constraints) (page 1 of 4).

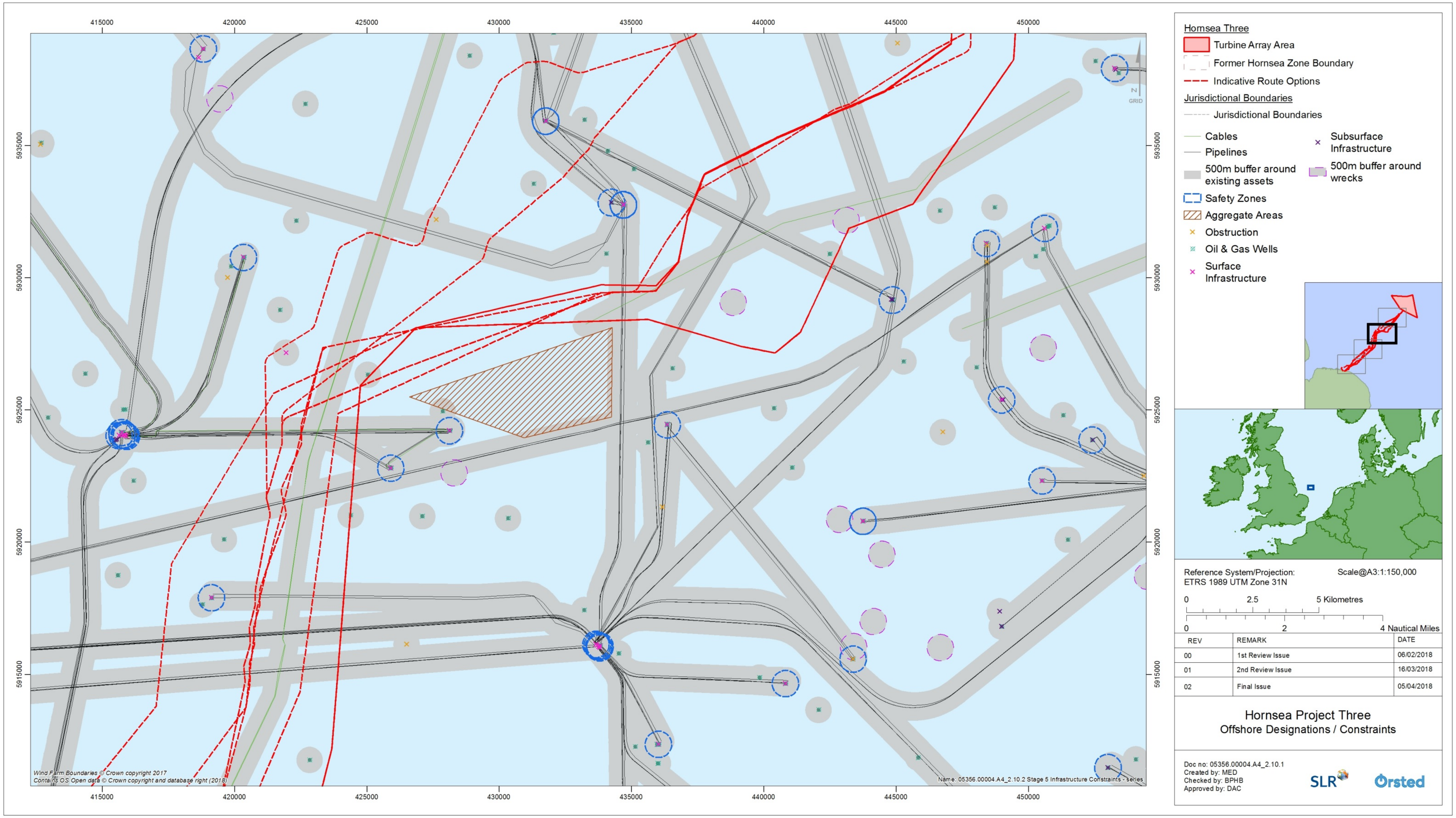


Figure 5.3: Stage 5 – ECR offshore corridor options (Infrastructure constraints) (page 2 of 4).

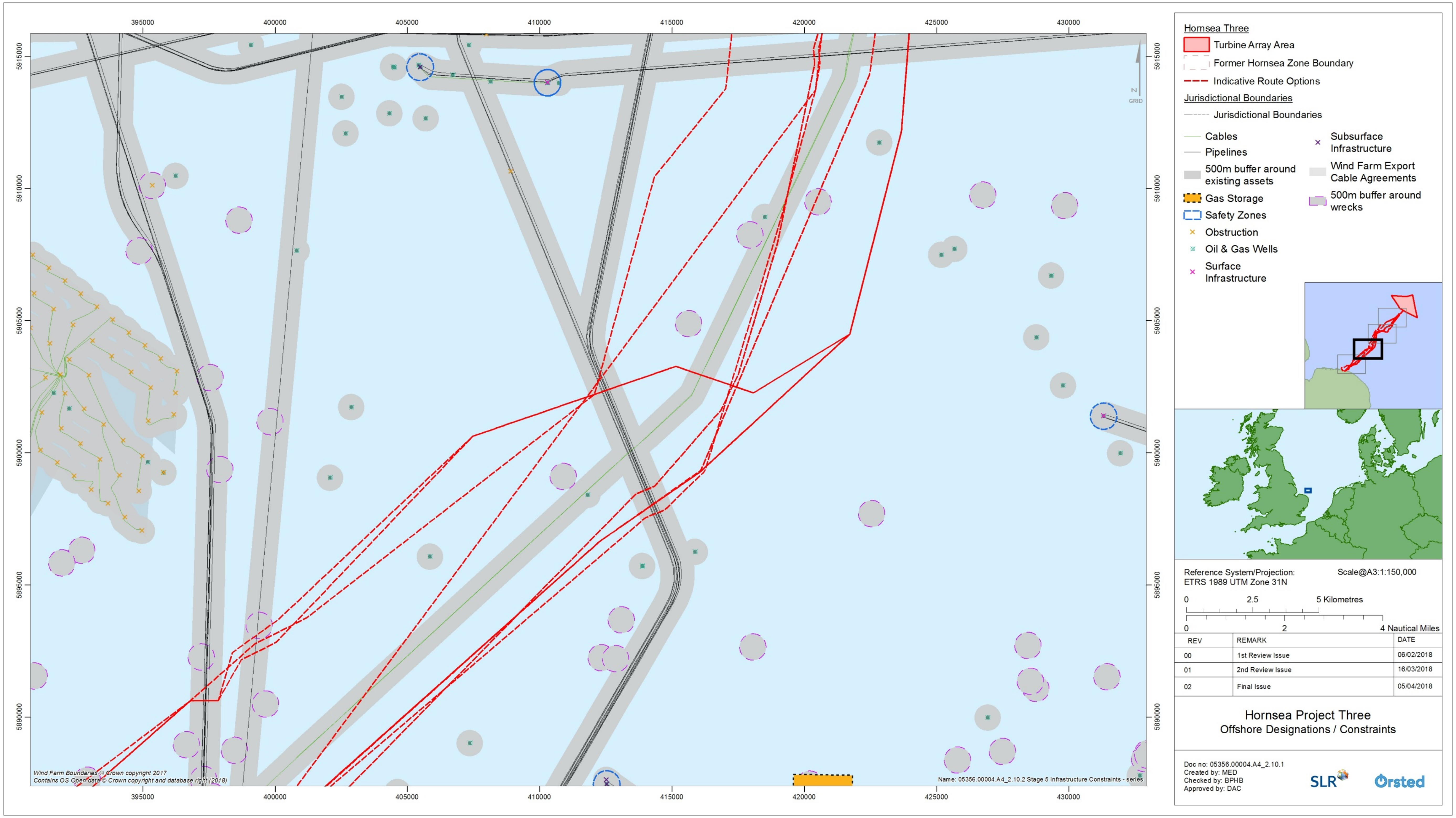


Figure 5.4: Stage 5 – ECR offshore corridor options (Infrastructure constraints) (page 3 of 4).

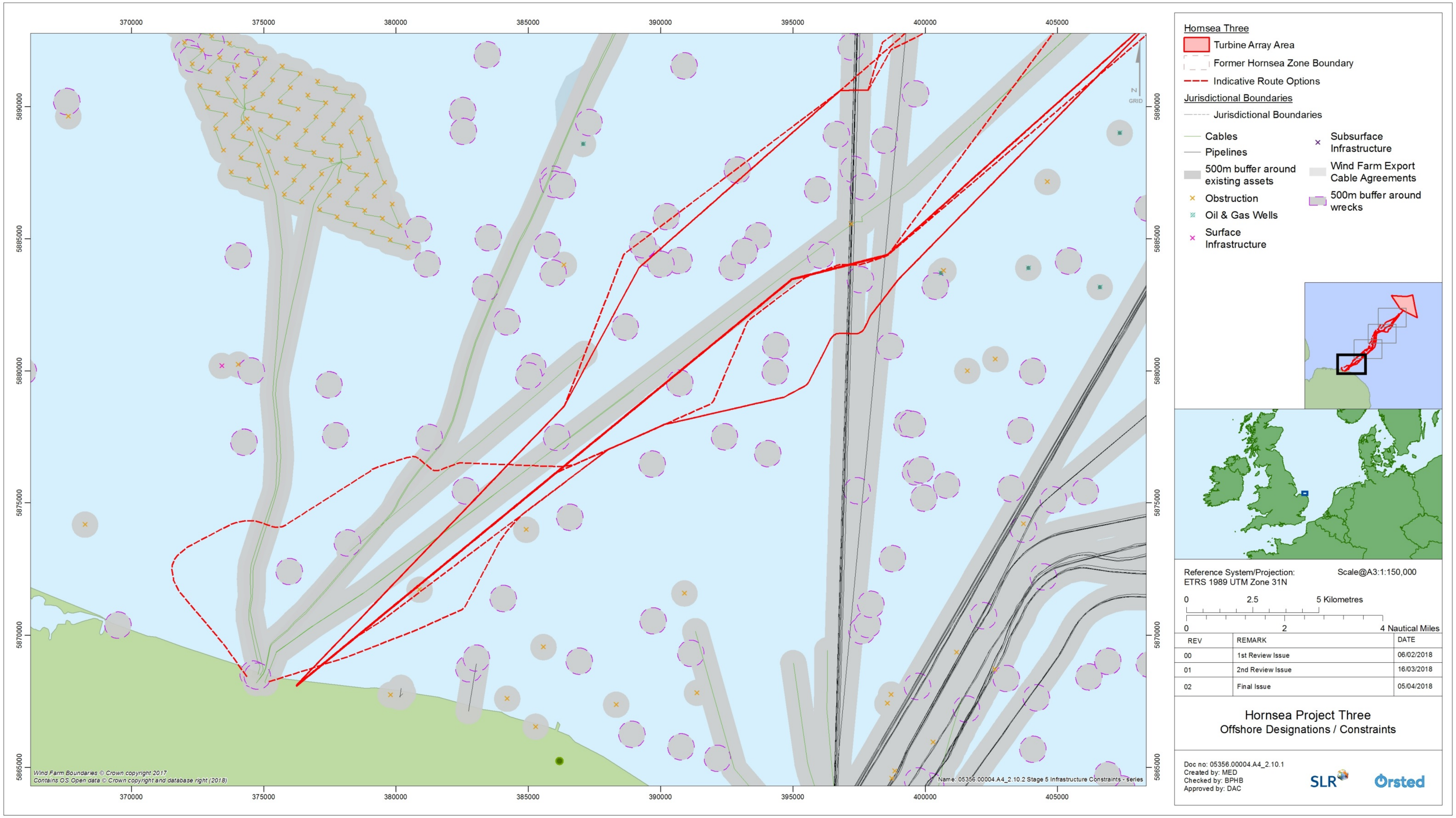


Figure 5.5: Stage 5 – ECR offshore corridor options (Infrastructure constraints) (page 4 of 4).

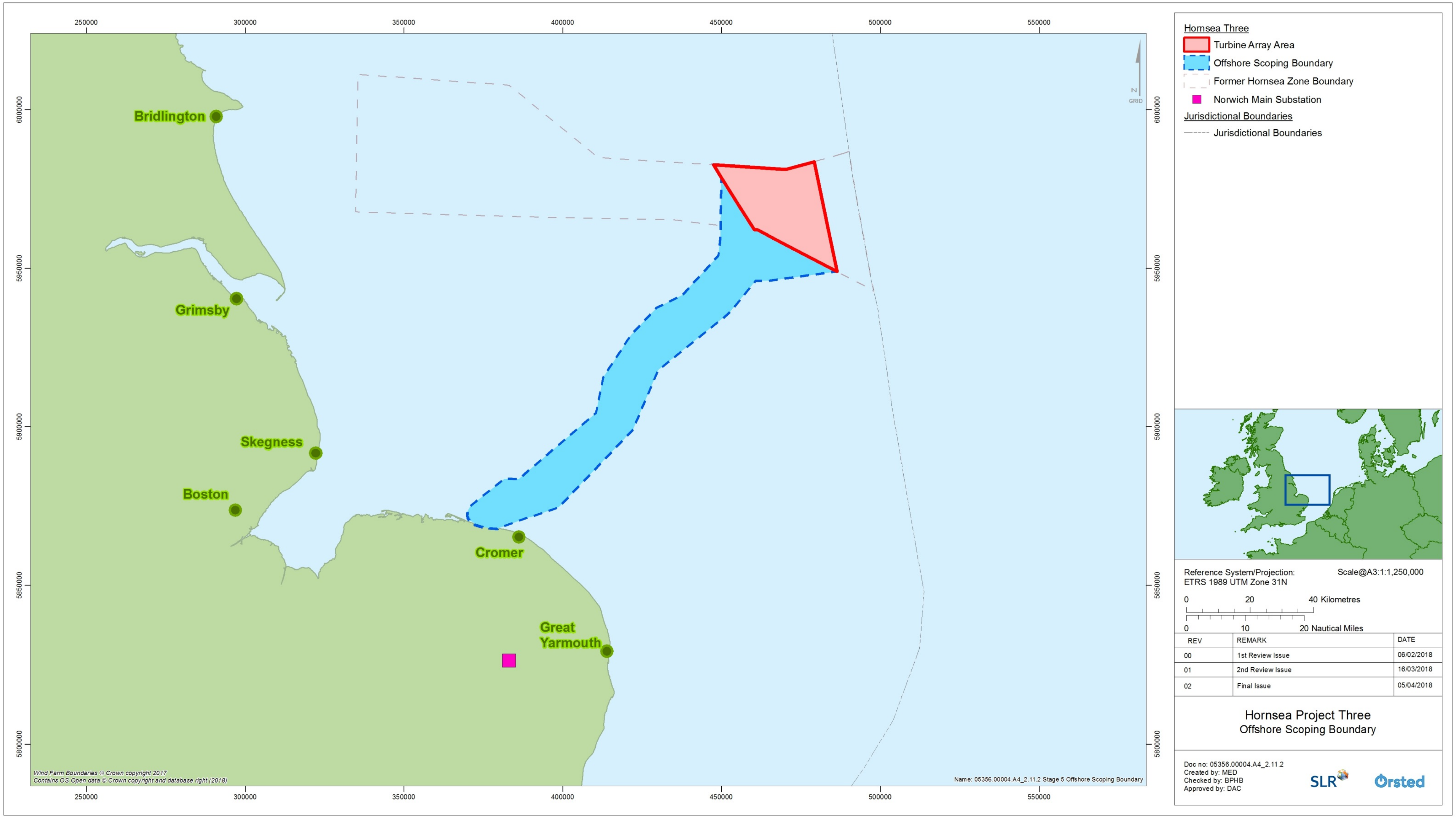


Figure 5.6: Offshore scoping boundary.

# 6. Stage 6 – Selection of Preferred Offshore ECR Corridor and HVAC Booster Station Search Area

## 6.1 Introduction

6.1.1.1 The aim at this pre-PEIR stage was to establish a preferred offshore ECR corridor and HVAC booster station search area through the detailed assessment of physical constraints to allow the Project sufficient confidence in order to commission site specific surveys. The ECR corridor funnels out at the proposed landfall in the vicinity of Weybourne and at the offshore array area to allow flexibility as plans were further developed.

## 6.2 Offshore ECR Corridor

### 6.2.1 Considerations

6.2.1.1 In order to establish a preferred offshore ECR corridor boundary, the following principles were applied to the route refinement process:

- Minimise overlap with the key features of the NNSSR SAC (in particular the sandbank features) - Routeing cables over large sandbank features can be technically challenging due to the potential of sediment moving during the life of the project potentially leaving cables exposed;
- Minimise overlap with the key (chalk) features of the Cromer Shoal MCZ; and
- Minimise the number of cable/pipeline crossings and ensure they occurred at as close to 90 degrees as possible.

### 6.2.2 Route Development

6.2.2.1 Figure 6.1 presents a 1.5 km wide corridor that was primarily constrained by the need to limit interaction with other linear infrastructure assets (cable/pipelines) where possible. Having been previously considered at earlier stages in the process this took the form of route refinement in response to the consideration of the two major factors at this stage, avoiding interaction with the sandbank features of the NNSSR SAC and key (chalk) features of the Cromer Shoal MCZ.

*North Norfolk Sandbank and Saturn Reef SAC*

6.2.2.2 The North Norfolk Sandbanks are the most extensive example of the offshore linear ridge sandbank type in United Kingdom (UK) waters, extending from about 40 km (22 nautical miles) off the coast out to approximately 110 km (60 nautical miles). Considered as a representative functioning example of the Annex I (Directive 92/43/EEC) feature, sandbanks which are 'slightly covered by sea water all the time', the designated boundary of the site encompasses the whole linear sandbank system rather than attempting to separate out individual banks. Due to their widespread coverage, rather than avoiding features altogether, route selection attempted to minimise potential impacts on the larger sandbanks which occurred predominantly to the south and east of the offshore ECR (See Figure 6.2, Figure 6.3 and Figure 6.4). Avoiding the larger sandbanks also brought a technical benefit in reducing the challenge of potential sediment movement during the life of the project which could potentially leave cables exposed.

*Cromer Shoal Chalk Beds MCZ*

6.2.2.3 In the nearshore area, the proposed routeing gave due consideration to the potential to overlap with the key (chalk) features of the Cromer Shoal Chalk Beds MCZ (See Figure 6.5). The Cromer Shoal Chalk Beds are an inshore site 200 m off the North Norfolk Coast extending from west of Weybourne to Happisborough. The site protects seaweed-dominated infralittoral rock which are an important habitat in shallow water.

6.2.2.4 The preferred ECR corridor at this stage presents two options, a more direct route to the east and a western ECR corridor which, based on available data at the time, sought to minimise interaction with the chalk which was considered to occur predominantly to the east of the offshore ECR. The alignment of the western ECR corridor was influenced by the need to cross and avoid interactions with existing infrastructure including cable connections from existing offshore windfarms.

## 6.3 Offshore HVAC Booster Station Considerations

### 6.3.1 Identification of a Search Area

6.3.1.1 An area (1.5 km wide) starting at approximately 40% of the total cable route length (offshore and onshore) and continuing to approximately 60% of the total cable route length, has been identified as the offshore HVAC booster station location search area (see Figure 6.6). This area, spanning 43.35 $km^2$, has been chosen based on the location potentially being electrically optimal. The final location of the offshore HVAC booster stations will be defined in the detailed design stage, post consent.

6.3.1.2 The siting will take into account stakeholder input, final electrical design, water depth, ground conditions and other engineering and economic factors to ensure a location is chosen to minimise impact to the human and natural environment as well as minimising cost of electricity and project risk.

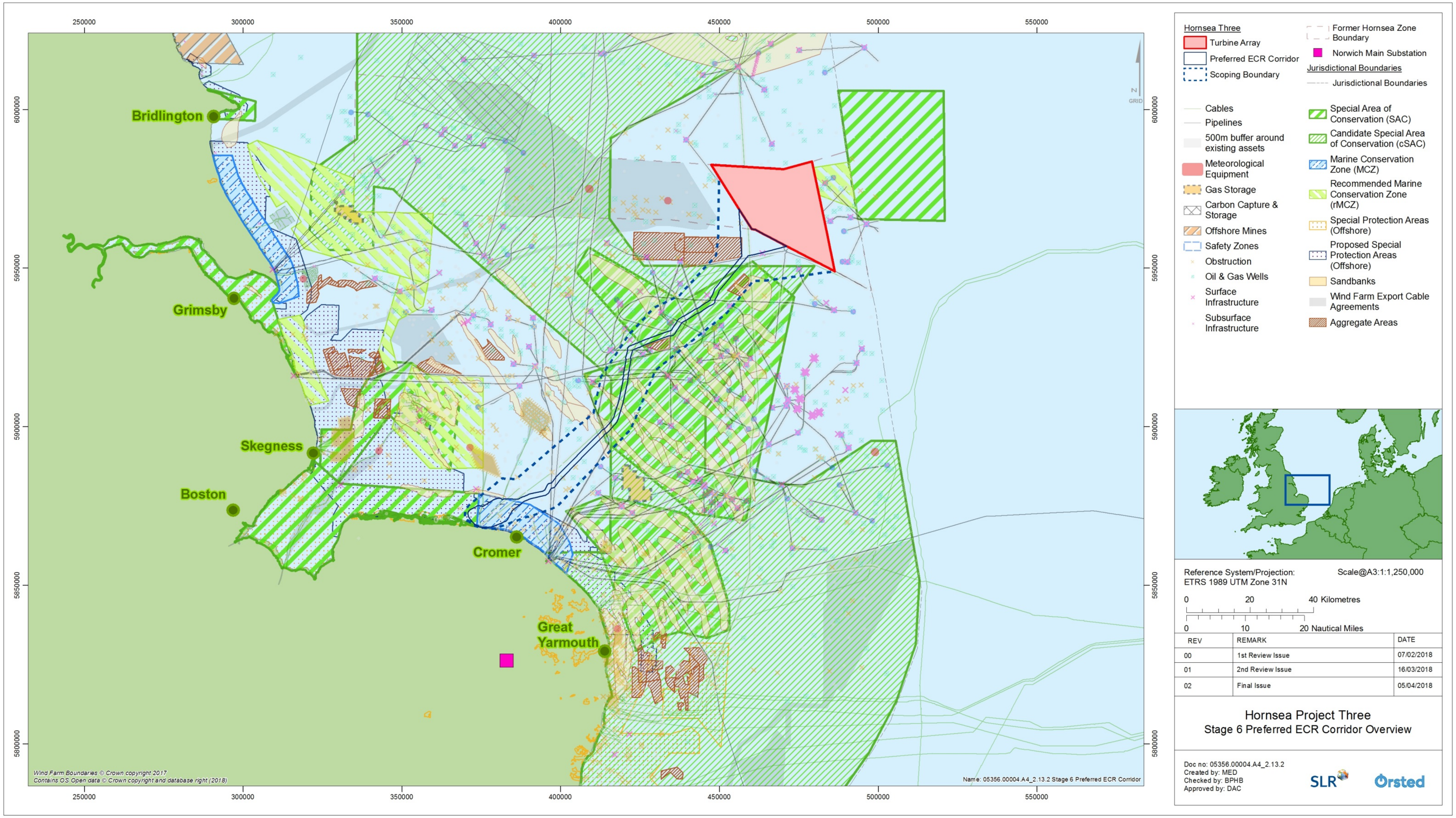


Figure 6.1: Stage 6 – Preferred ECR corridor overview.

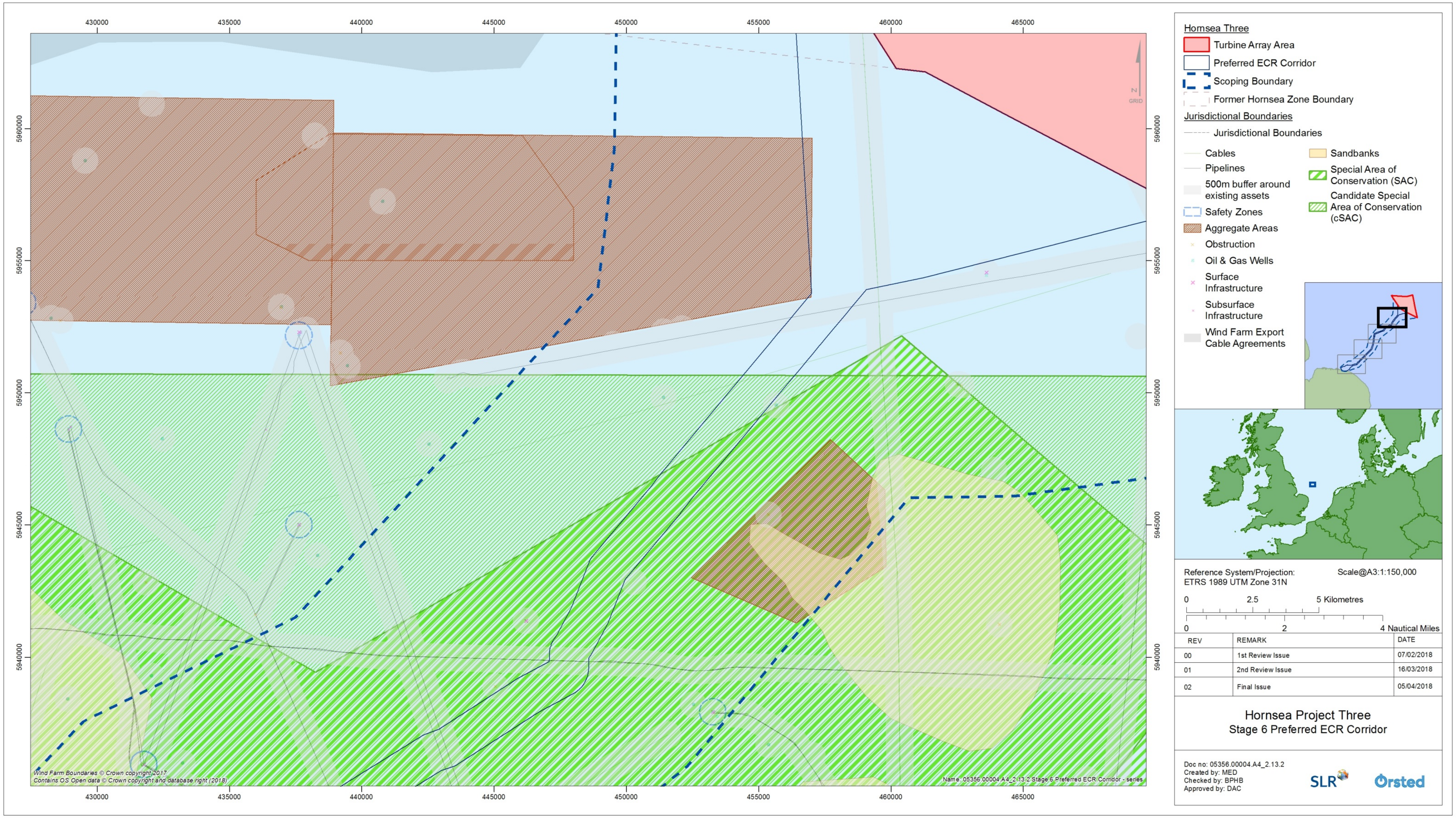


Figure 6.2: Stage 6 – Preferred ECR corridor (page 1 of 4).

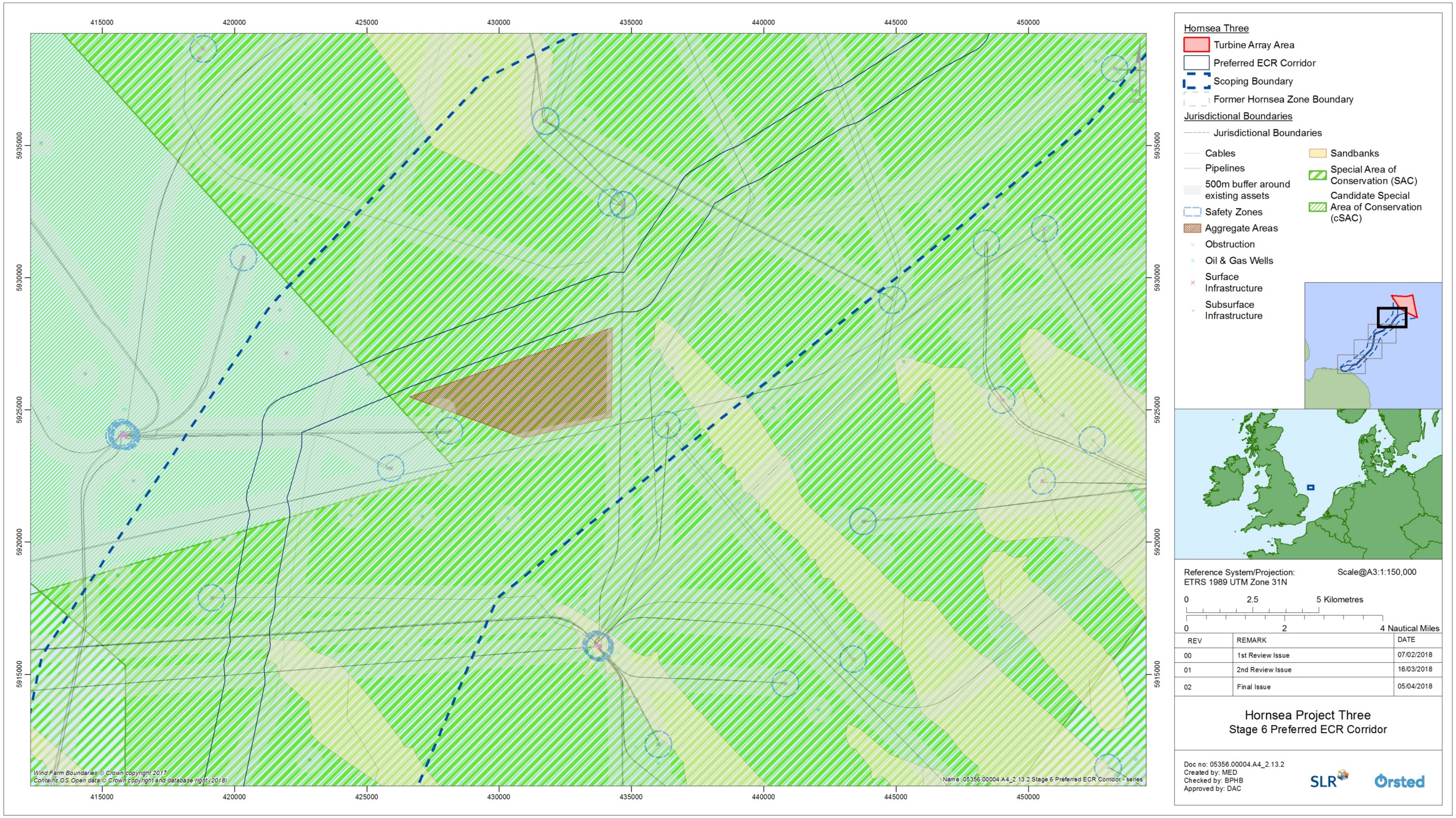


Figure 6.3: Stage 6 – Preferred ECR corridor (page 2 of 4).

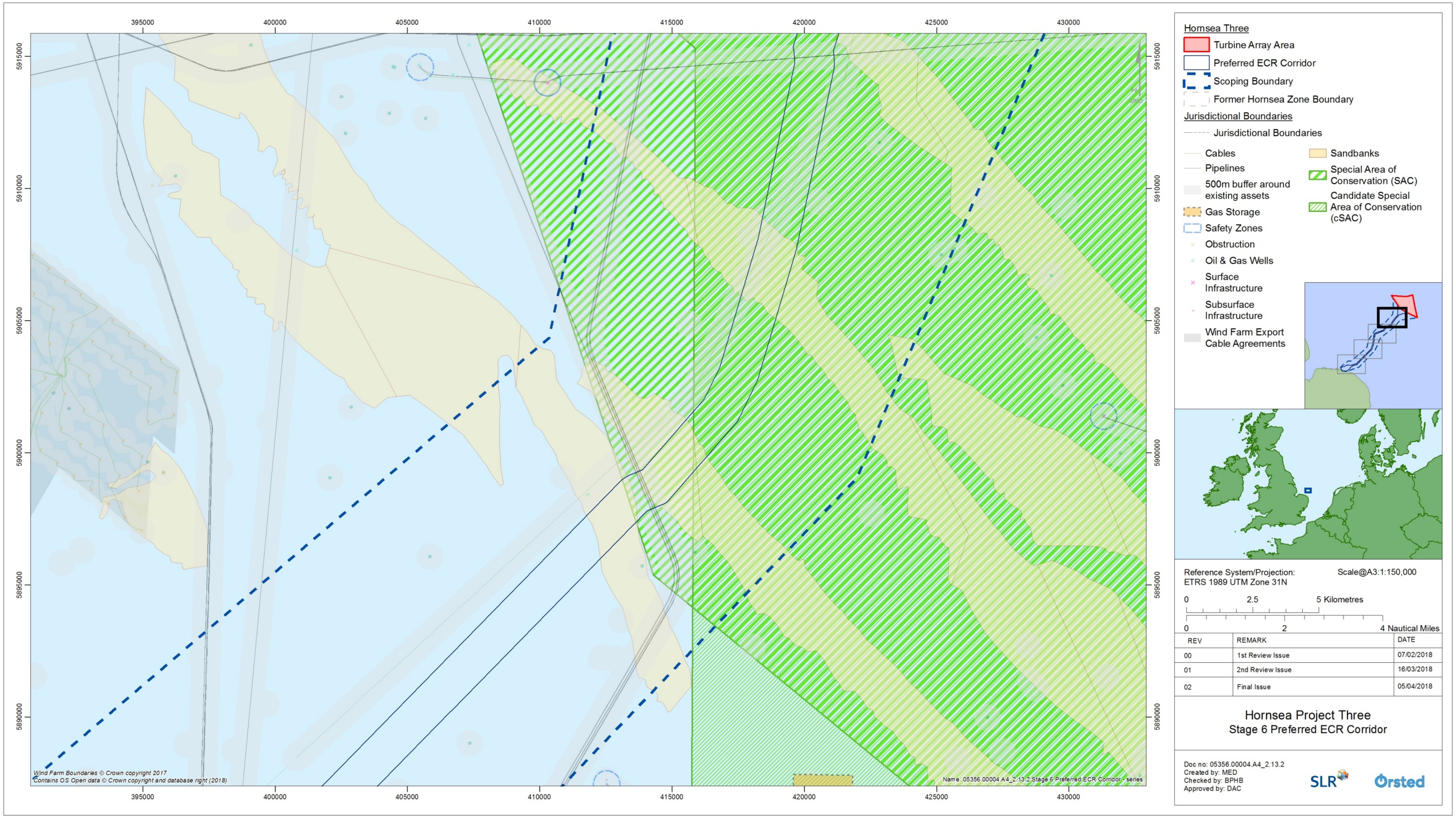


Figure 6.4: Stage 6 – Preferred ECR corridor (page 3 of 4).

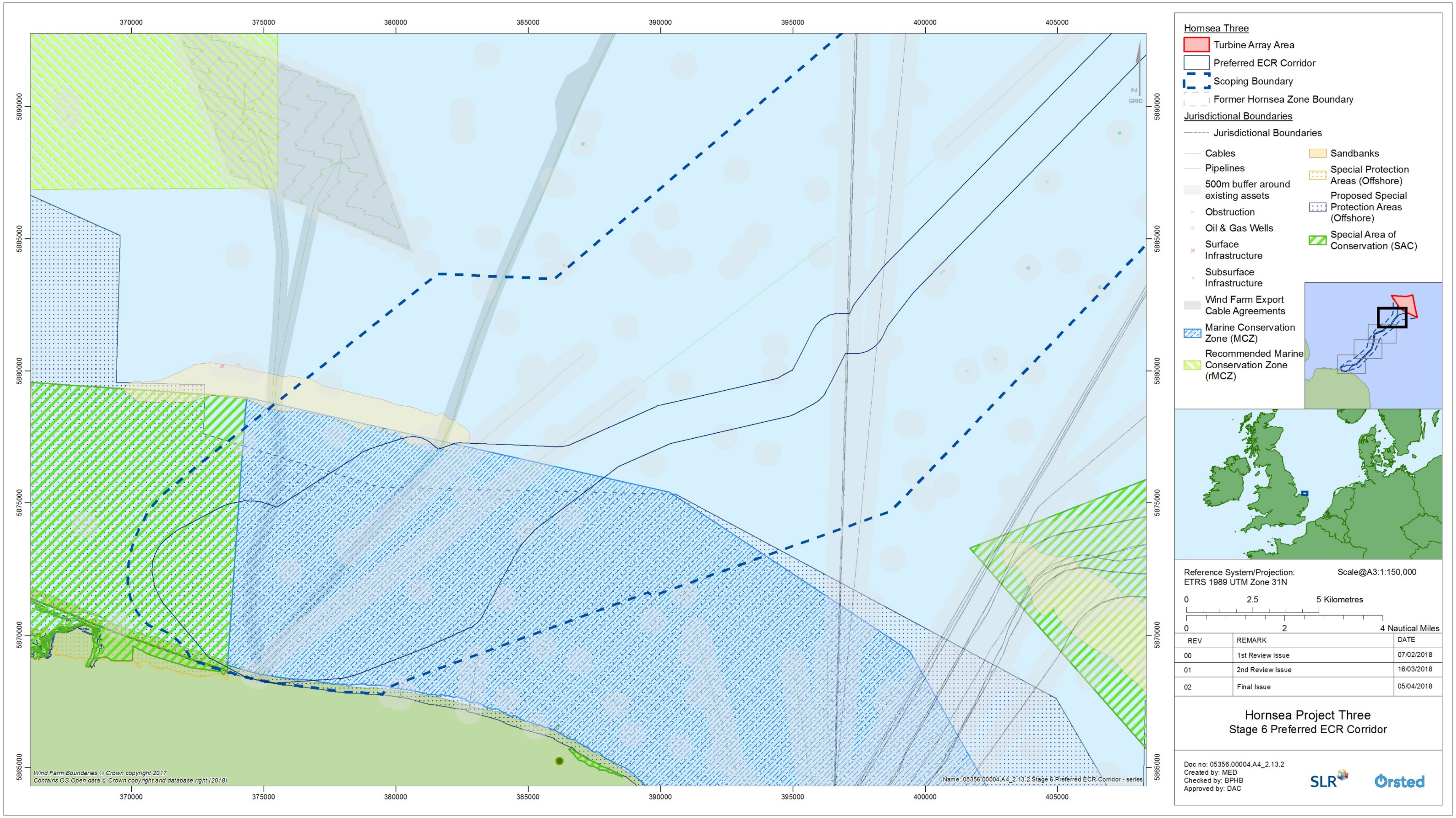


Figure 6.5: Stage 6 – Preferred ECR corridor (page 4 of 4).

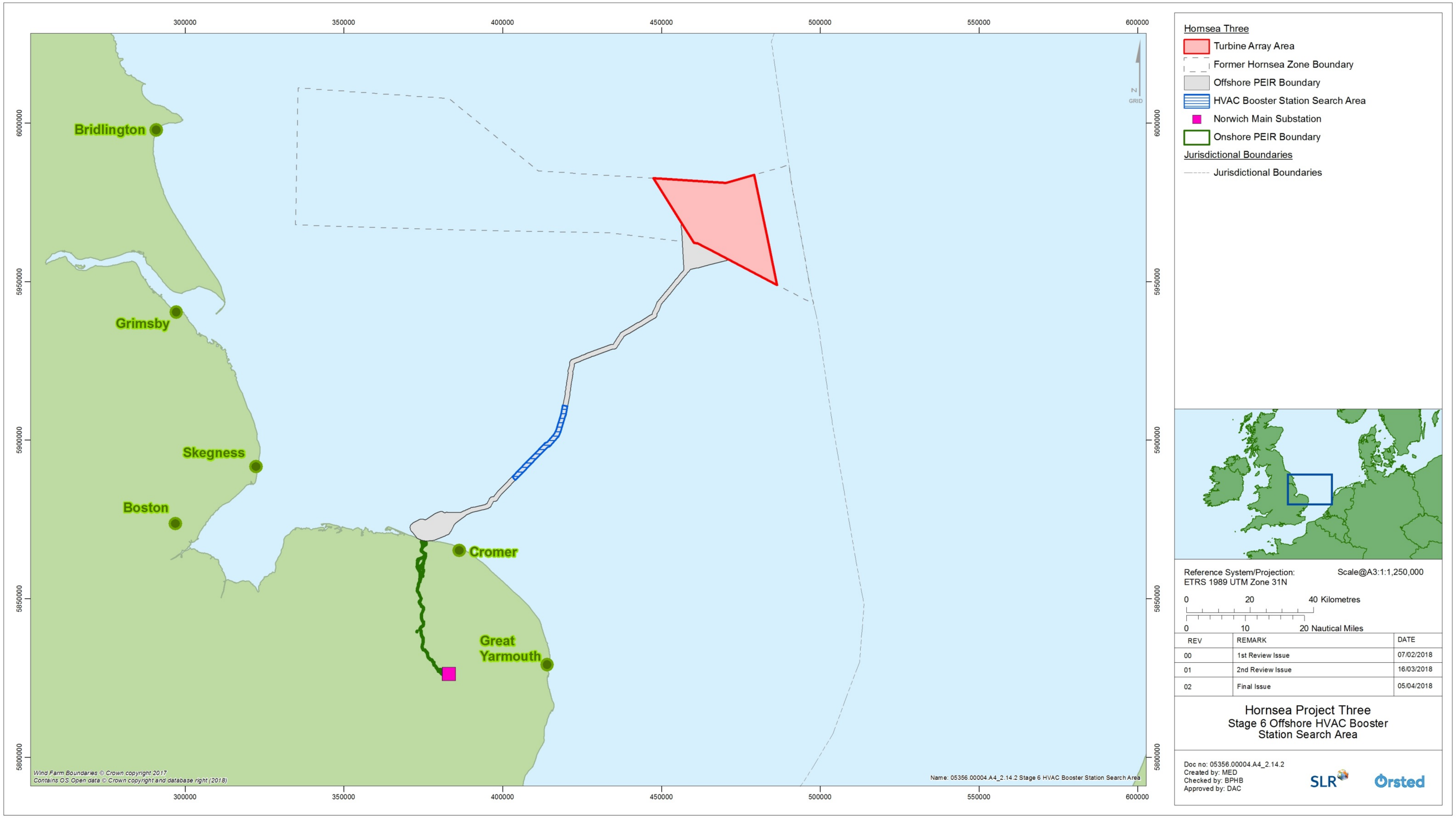


Figure 6.6: Stage 6 – Offshore HVAC booster station search area.

# 7. Stage 7 – Refinement of Site Selection for PEIR Submission

## 7.1 Considerations

7.1.1.1 A 600 m temporary working area was incorporated either side of the 1.5 km route corridor (See Figure 7.1) to ensure that any vessels associated with the installation of the export cables and/or the offshore HVAC booster station, could operate within close proximity to the main ECR corridor boundary without risk of their anchors or jack-up legs being outwith the consented order limits.

7.1.1.2 The two route options towards the nearshore area within the Cromer Shoal MCZ, as well as the area in between were encapsulated within the PEIR boundary. The area in between was added in response to stakeholder concerns at that point in time (prior to data collection in the area) over the location of key features of conservation interest as it was considered that this could later aid further refinement to potentially avoid such features if found during surveys.

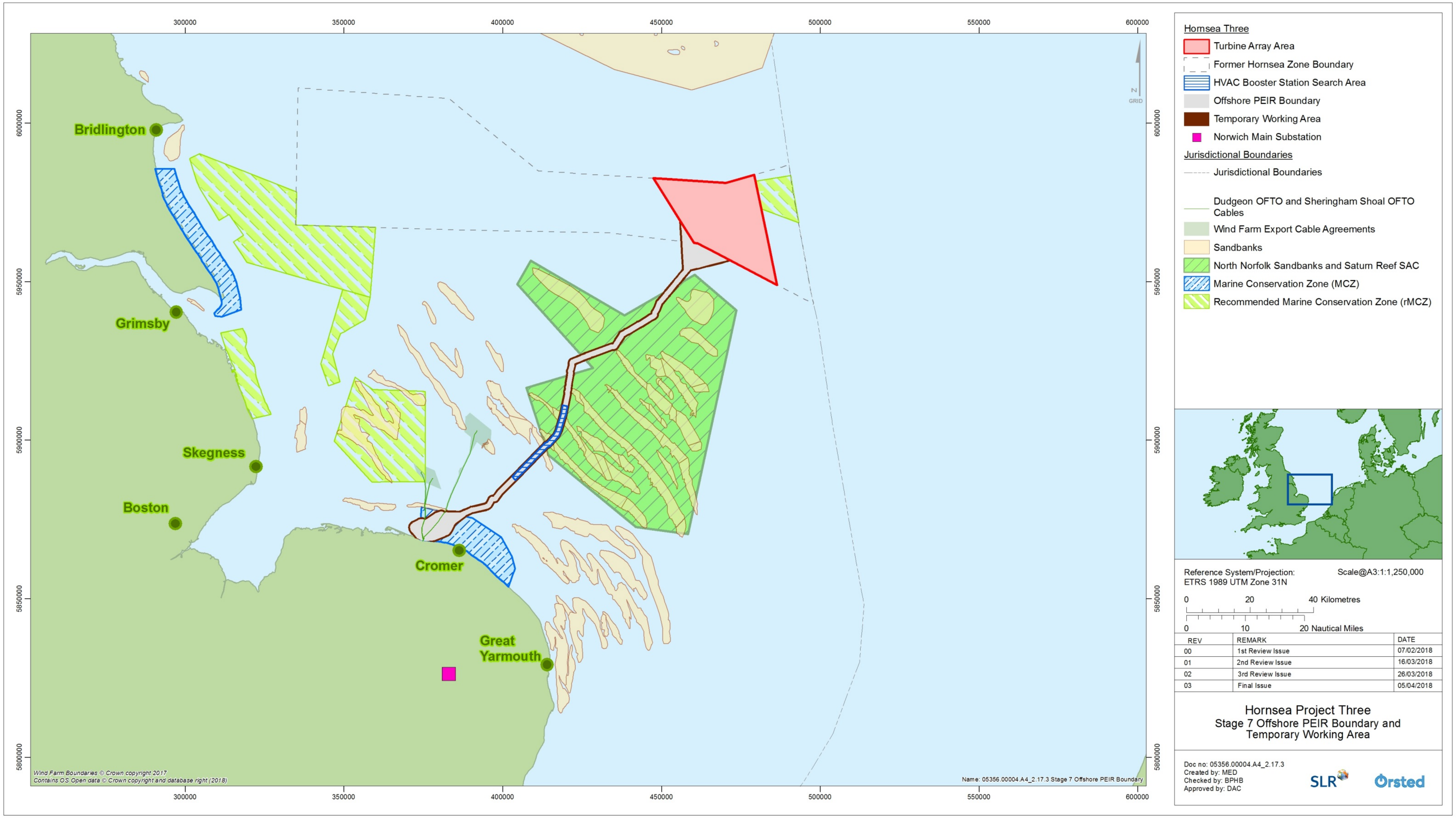


Figure 7.1: Stage 7 – Offshore PEIR boundary with temporary working area.

# 8. Stages 8 and 9 – Further Refinement of the Offshore ECR Corridor and Offshore HVAC Booster Station

## 8.1 Introduction

### 8.1.1 Background

8.1.1.1 Following feedback received during statutory consultation (July-Sept 2017), site selection was reviewed specifically in relation to routeing within the following two sensitive areas:

- NNSSR SAC; and
- Cromer Shoal Chalk Beds MCZ.

### 8.1.2 North Norfolk Sandbanks and Saturn Reef SAC

8.1.2.1 With the proposed ECR corridor routeing through the NNSSR SAC, Natural England felt that the PEIR should have explained how impacts could be avoided or mitigated. Due to the lack of information available at that stage, Natural England felt that it was not possible to exclude an adverse effect on the integrity of the designation. In particular, Natural England expressed a preference to push the route further to the west into the protruding western boundary of the site.

### 8.1.3 Cromer Shoal Chalk Beds MCZ

8.1.3.1 During the early stages of site selection, a decision was made to avoid the European designated Wash and North Norfolk Coast (WNNC) SAC in favour of routeing through the nationally designated Cromer Shoal Chalk Beds MCZ for the majority of the proposed route. This also lead to a shorter total ECR which was considered to be economically preferable. For the purposes of defining the PEIR boundary (Stage 7), two ECR corridor options were established within the MCZ in order to reach landfall zone 2 (See Figure 6.5), one more direct route to the east, and another to the west which avoided more of the MCZ's marine interest features.

8.1.3.2 Through s42 statutory consultation, Natural England subsequently advised that the marine interest features of the SAC could be less sensitive than those within the MCZ and it therefore may be preferable in some instances for the cables to route through the SAC rather than the MCZ.

## 8.2 Potential Offshore Alternative Routes

8.2.1.1 Taking on board s42 consultation feedback from a range of consultees, potential offshore alternative routes' were subsequently considered in these two broad locations, each located outside of the redline boundary previously consulted upon at scoping and PEIR submission.

8.2.1.2 One close to the array area affecting the NNSSR SAC, known as the 'seaward potential alternative route', and another closer to landfall which affected the MCZ, known as the 'near shore potential alternative route'.

8.2.1.3 These routes were presented in a stage of official Further Statutory Consultation (Phase 2.B) that took place in November to December 2017).

### 8.2.2 Seaward potential alternative route

8.2.2.1 An initial route was considered to divert the ECR corridor outside of the NNSSR SAC entirely. However, this approach was discounted due to the additional consenting challenge associated with several active and licenced aggregate areas and the significant increase in cable length which precluded routeing to the north and west of the SAC.

8.2.2.2 An alternative option was subsequently proposed which considered a partial re-route to the north, taking the ECR corridor outside the SAC for a stretch of 25 km (Figure 8.1). It was considered that this would reduce the effects on the SAC and would also be achievable from a technical perspective.

### 8.2.3 Nearshore potential alternative route

8.2.3.1 The nearshore ECR corridor option deviated from the original route at approximately 32 km from the landfall. From this point it ran broadly in a westerly direction for approximately 22 km, crossing the Dudgeon and Sheringham Shoal export cables, before turning route for 2 km before it enters the WNNC SAC. Continuing south for approximately 4 km it then re-joins the original ECR corridor within the MCZ (Figure 8.1). See volume 2, chapter 2: Benthic Ecology for further information.

### 8.2.4 Further Consultation Feedback

8.2.4.1 A supplementary information document was produced to provide further information on the 'potential offshore alternative routes'. This supporting information outlined the data sources and presented the baseline characteristics of the area as well as setting out the next steps in the DCO process.

8.2.4.2 Consulted on following its publication in November 2017, the proposed 'seaward potential alternative route' was seen to reduce the direct impact to the NNSSR SAC due to cable laying activities. While it was acknowledged that it did not fully remove the ECR corridor from the designated site, it was viewed as an appropriate means to mitigate impacts to the northern most area of the NNSSR SAC.

8.2.4.3 The proposed 'nearshore potential alternative route' was seen to avoid impacts on the features of Cromer Shoal Chalk Bed MCZ, however further information was requested by the MCZ Working Group[1] in the form of a comparison between the alternative route and the original route given the latter's greater interaction with the WNNC SAC.

### 8.2.5 Route Comparison

8.2.5.1 In December 2017 a meeting was held with the Marine Processes, Benthic Ecology and Fish and Shellfish Ecology Expert Working Group (EWG) followed by a MCZ workshop to consider the implications of any potential near shore route change on the WNNC SAC and the Cromer Shoal Chalk Beds MCZ. The working group requested further clarification on the approach to baseline characterisation for the near shore area, including how desktop data sources were to be used to support the Hornsea Three site specific survey data.

8.2.5.2 A note was produced which explained how drop down video (DDV), benthic grab and beam trawl sampling, with geophysical interpretation, were analysed and used to identify and map biotopes across the entire Hornsea Three Project area, including the original near shore section of the ECR corridor. A number of desktop data sources from the near shore area were reviewed to inform the benthic ecology characterisation, including:

- Sheringham Shoal offshore windfarm baseline characterisation and post construction monitoring data (Scira Offshore Energy Ltd., 2006 and 2014);
- Dudgeon offshore wind farm export cable data (Dudgeon Offshore Wind Limited, 2009);
- Natural England data for the SAC (APEM, 2013);
- Data from Magic.defra.gov.uk and Marine Recorder (including Seasearch reports and data from the MCZ and SAC); and
- Data from the Cromer Shoal Chalk Beds MCZ (Defra, 2015).

8.2.5.3 The note also sought to respond to concerns shown by Natural England with regards to the incorporation of data from the monitoring programme for Sheringham Shoal and surveys of both Sheringham Shoal and Dudgeon.

8.2.5.4 In comparing the two routes the following key points were established:

- Although the potential near shore alternative route would result in an increase in the length of cable passing through the WNNC SAC (i.e. an increase from ~7 km to ~11 km), the total length of cable passing through both the WNNC SAC and the MCZ combined is reduced by almost half;
- The maximum area of seabed within designated sites which may be affected by cable protection (including crossings) within the potential near shore alternative route would be approximately one quarter of that using the original route, with much of this reduction due to all cable crossings being located outside both the SAC and MCZ;
- While the potential nearshore alternative route would result in an increased impact on the WNNC SAC, this is the western periphery of the SAC and the areas (habitats/biotopes) affected are not qualifying features in their own right (although some are supporting habitats). In contrast, the original route would result in effects on protected MCZ features; and
- The potential nearshore alternative route would move construction activities further away from the more intense areas of fishing activity and is therefore supported by the Eastern Inshore Fisheries and Conservation Authority (IFCA).

[1] A stakeholder working group focussing on the project's potential impacts on MCZs, comprising representatives from Natural England, the MMO, The Wildlife Trusts and the Planning Inspectorate.

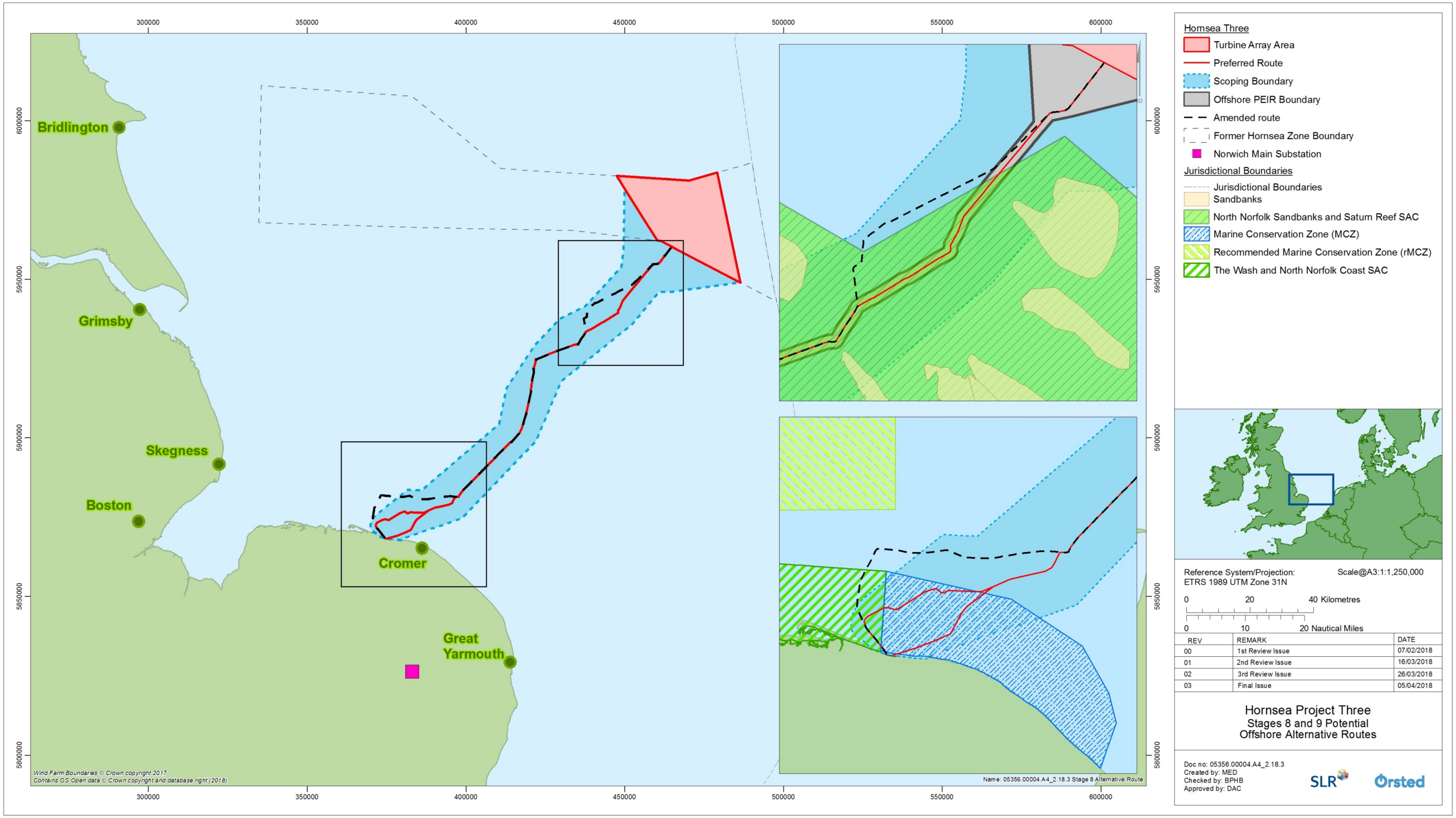


Figure 8.1: Stages 8 and 9 – Potential offshore alternative routes and preferred offshore booster station location.

## 8.3 Offshore HVAC Booster Station

### 8.3.1 Search Area Refinement

8.3.1.1 Hornsea Three requires up to four HVAC booster stations (six if subsea) within the HVAC booster atation search area. There should be a minimum separation of 100 m bridge links. For the purpose of the HVAC refinement process, layout may be in a grid, string or randomised. Therefore the surface area range required for the layout of the booster stations would be between 100 $m^2$ and 1.5 $km^2$. In order to establish a refined search area, the following key constraints were considered:

- Bathymetry;
- Shipping; and
- Designated sites.

Bathymetry

8.3.1.2 Bathymetry and seabed sediments were considered to be a key constraint where water depths are over 50 m and/or seabed sediments are characterised by exposed bedrock or heterogenous Quaternary till units with a high volume of erratic/boulders. The bathymetry in the HVAC booster station search area and surrounding environs is shown within Figure 8.2. The area is characterised by the presence of southeast to northwest trending sandbanks, typically 10-20 m from trough to crest. Water depths are typically in the range of 20 – 30 m, though are reduced on sandbank crests where they may be as shallow as 0-9 m and exceeded within troughs (30 m – 40 m).

Shipping

8.3.1.3 Shipping was the key human constraint to the refinement of the HVAC booster station search area. Figure 8.3 presents an overview of the marine traffic Automatic Identification System (AIS) and radar data within the search area (excluding temporary traffic (28 days summer and winter 2016)). Figure 8.4 presents the 90th percentile lanes and pre-Hornsea Three main routes within the search area. This information indicated that the southern extent of the search area possesses an increased shipping intensity relative to other areas of the search area (routes 4 and 5). While it should be noted that these shipping routes are indicative and do not constitute fixed shipping lanes, due to being areas of increased shipping intensity they were viewed as a constraint to avoid if possible.

Designated sites

8.3.1.4 NNSSR SAC overlapped spatially with the HVAC booster station search area presented at PEIR (See Figure 8.5) towards its northern extent. Siting permanent structures in this area was likely to lead to greater adverse environmental effects than locations outside the designated site and therefore by reducing the search area to remove this overlap, impacts on the designated site would be reduced.

Summary

8.3.1.5 A 21 $km^2$ outer search area was defined on the basis of it being approximately 4 times the area required (4.5 $km^2$) (See (Figure 8.6). With this being partially located within the NNSSR SAC, Natural England felt that this could still result in a location being selected that would lead to an impact on the protected site. It was felt that with other locations available outside of the SAC, a refined search area should be considered.

8.3.1.6 Subsequently, a smaller 7 $km^2$ area was identified which would avoid both the features of the designated site and shipping routes (Figure 8.7).

8.3.1.7 Using additional bathymetry data and assessment of ground conditions, final refinements were made to this small search area taking into consideration the proximity of sandbanks outside the SAC, which are deemed to be part of an interdependent morphodynamically linked system. In order to allow for this, the final search area was modified slightly, moving south to allow for one tidal excursion from the designated site (See Figure 8.8). This area was deemed to provide enough scope to maintain flexibility in project design while addressing the key technical and consenting issues.

## 8.4 Conclusion

8.4.1.1 The final offshore ECR corridor and associated HVAC booster station search area, as presented within this Annex, has been derived through a combination of physical and third party, seabed use and environmental considerations balanced alongside engineering limitations. Decisions have been made by a multi-disciplinary team taking into consideration consultation responses and feedback as well as detailed technical, commercial and environmental studies.

8.4.1.2 The final route taken forwards for this application for Development Consent is shown in volume 1, chapter 3: Project Description.

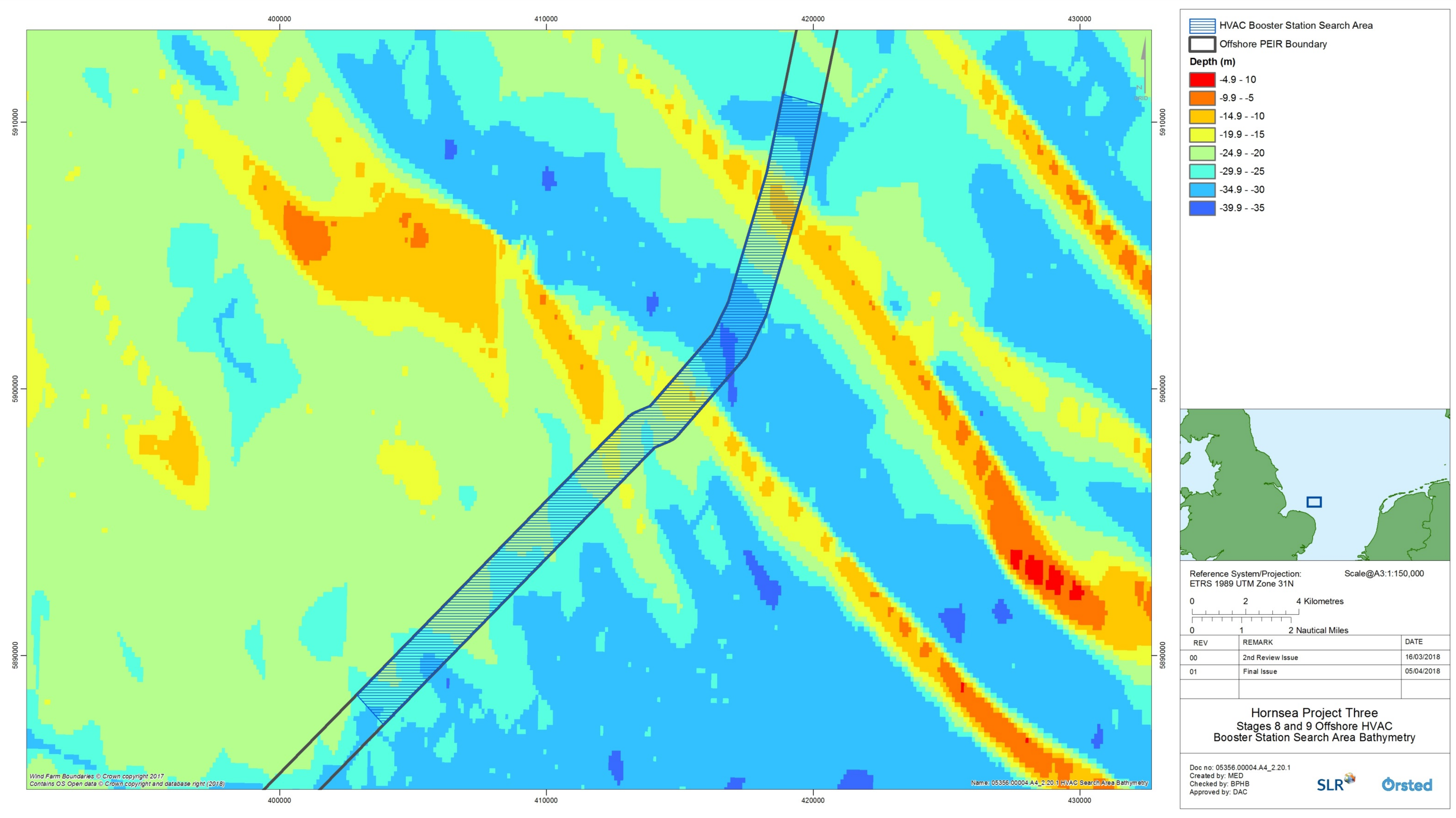


Figure 8.2: Stages 8 and 9 – Offshore HVAC booster station search area bathymetry (using PEIR search area boundary).

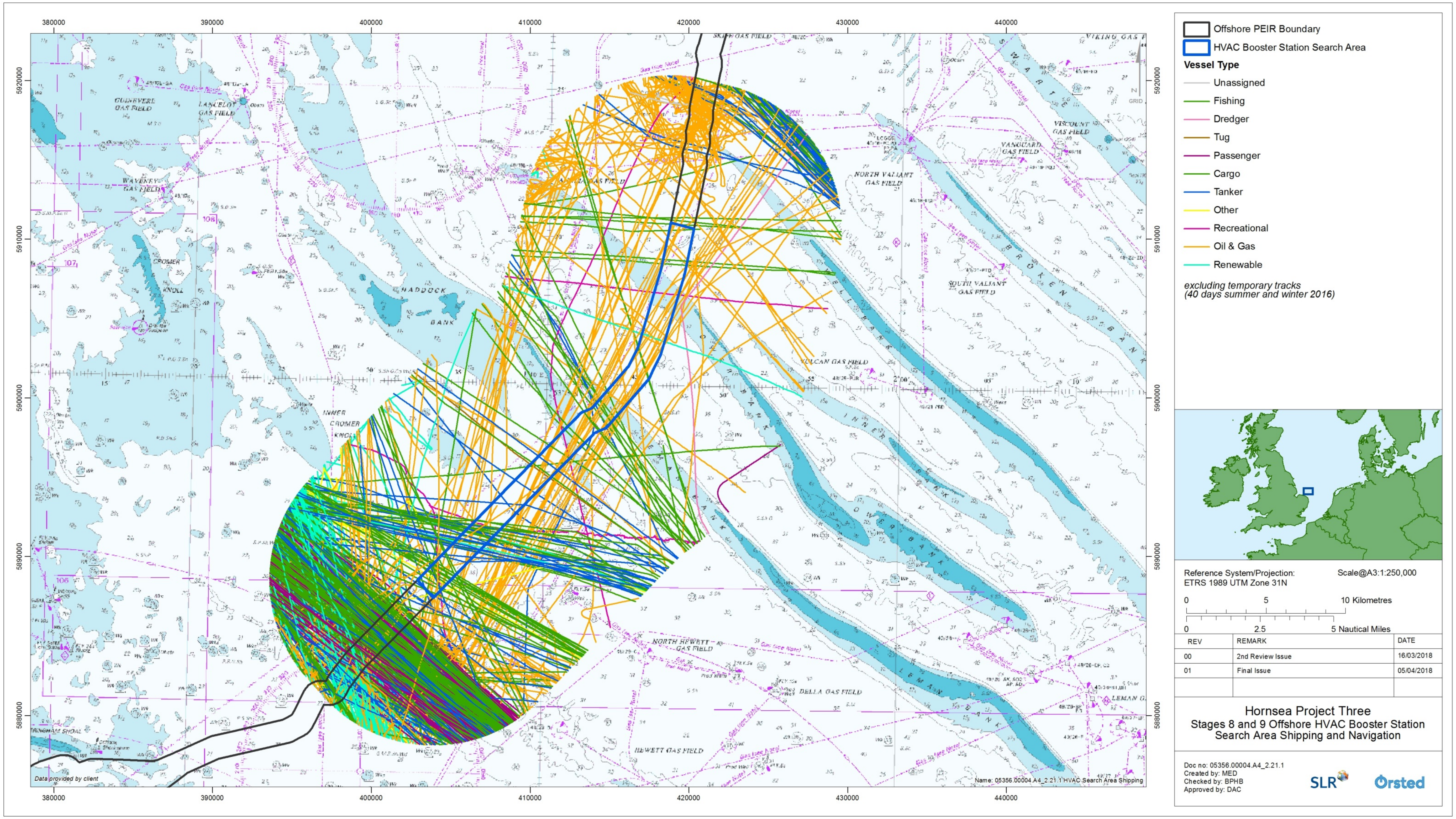


Figure 8.3: Stages 8 and 9 – Offshore HVAC booster station search area shipping and navigation (using PEIR search area boundary).

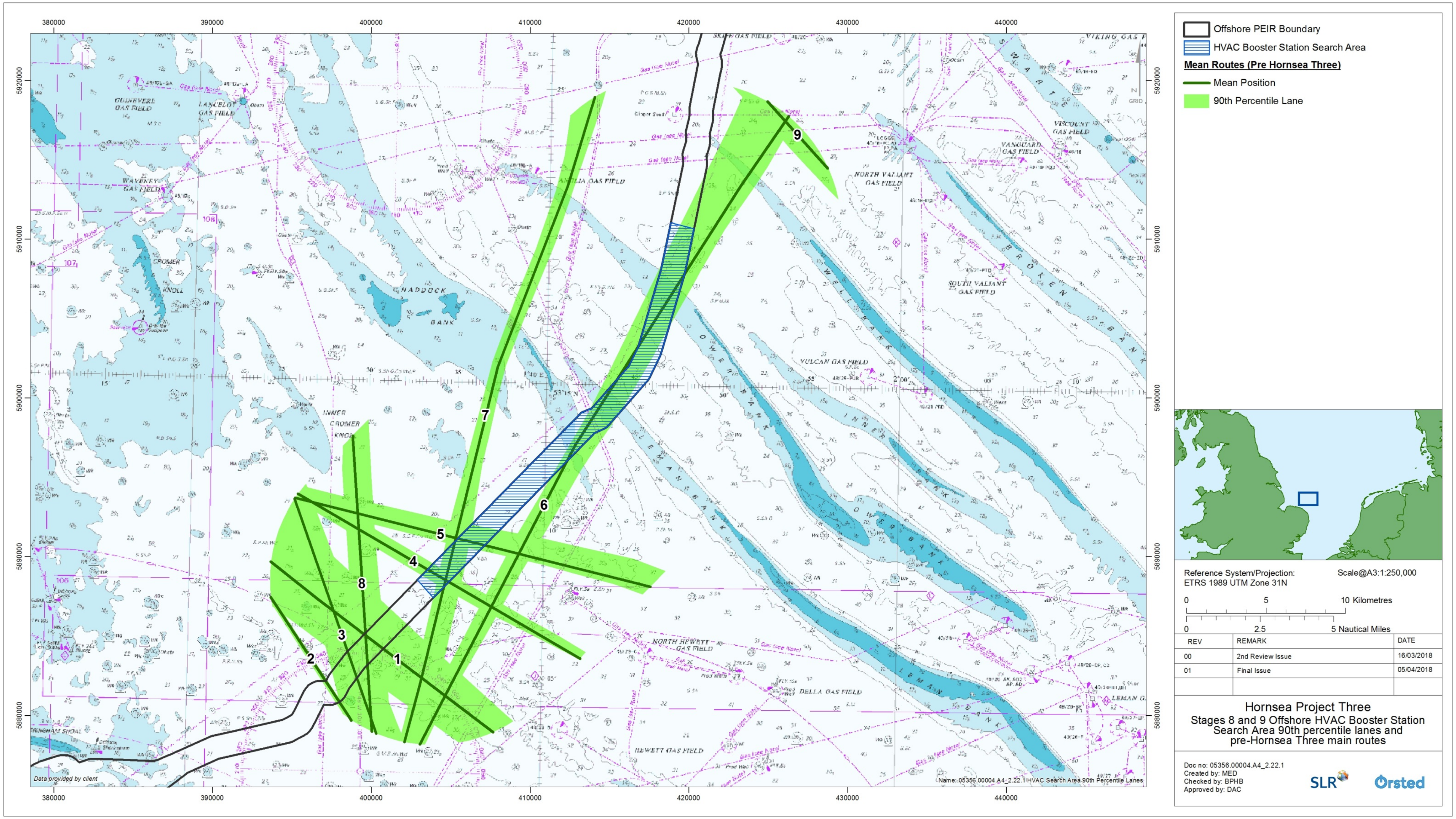


Figure 8.4: Stages 8 and 9 - Offshore HVAC booster station search area 90th percentile lanes and pre-Hornsea Three main routes (using PEIR search area boundary).

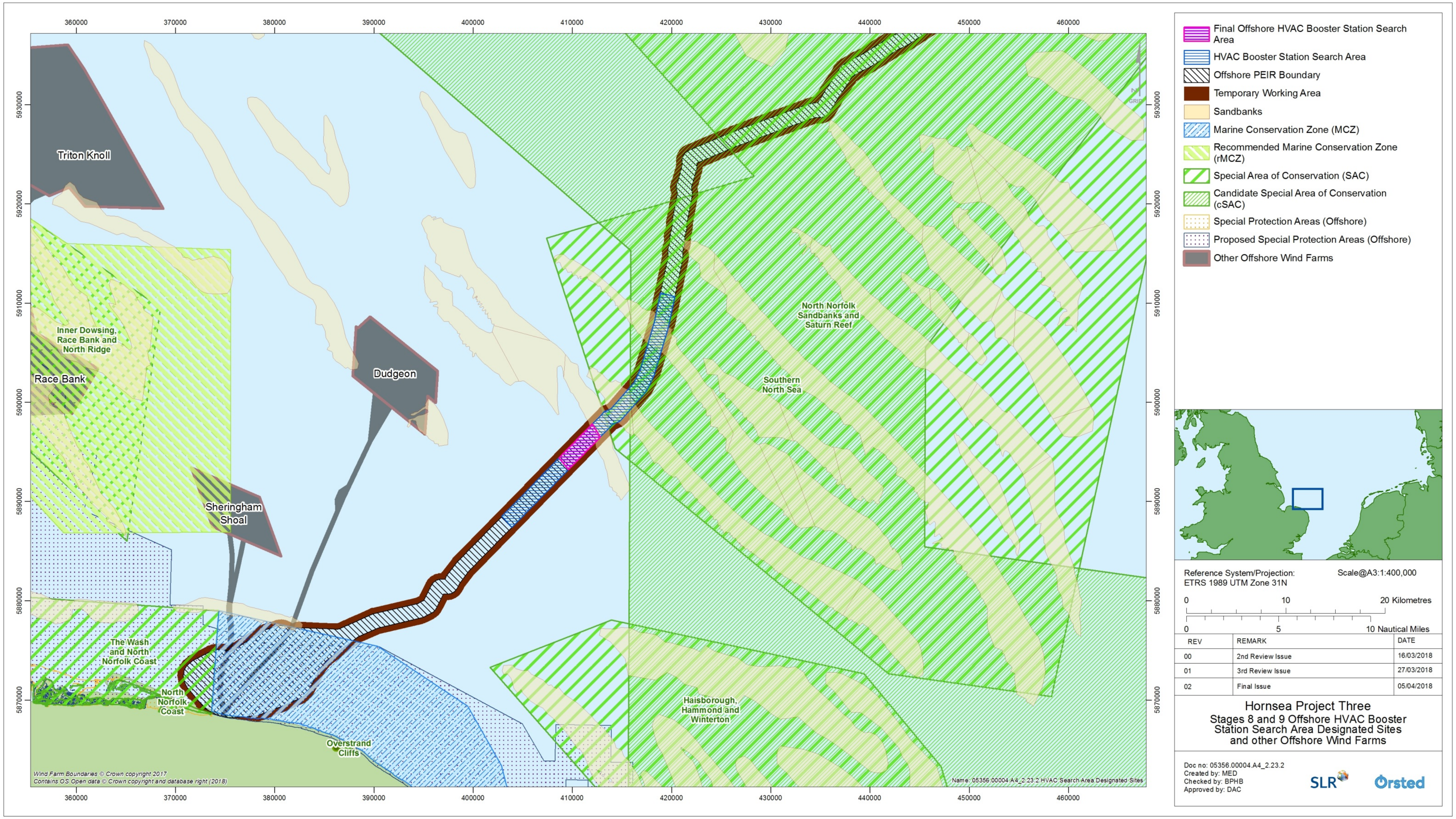


Figure 8.5: Stages 8 and 9 - Offshore HVAC booster station search area designated sites and other offshore wind farms (using PEIR search area boundary).

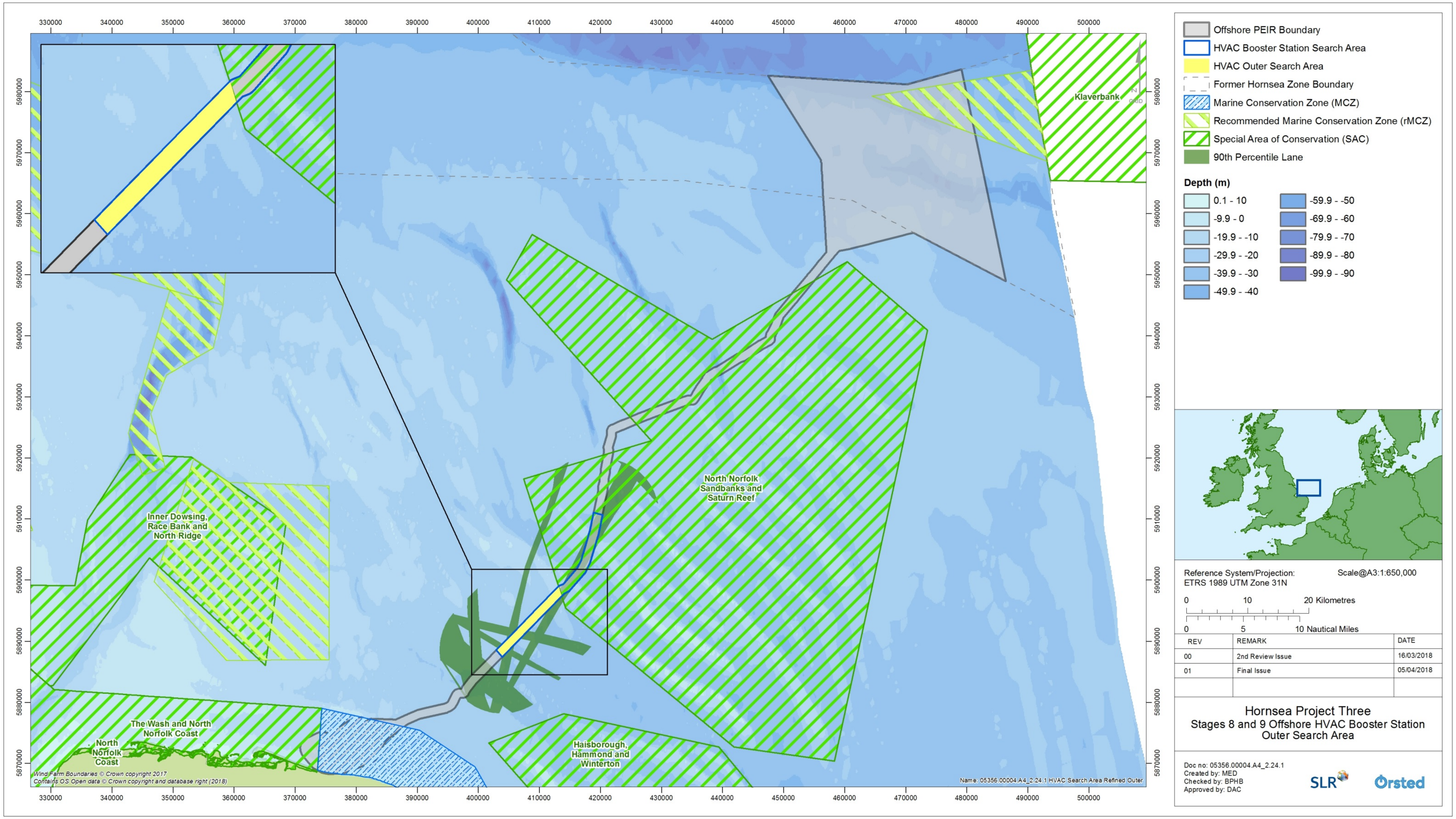


Figure 8.6: Stages 8 and 9 - Offshore HVAC booster station outer search area (using PEIR search area boundary).

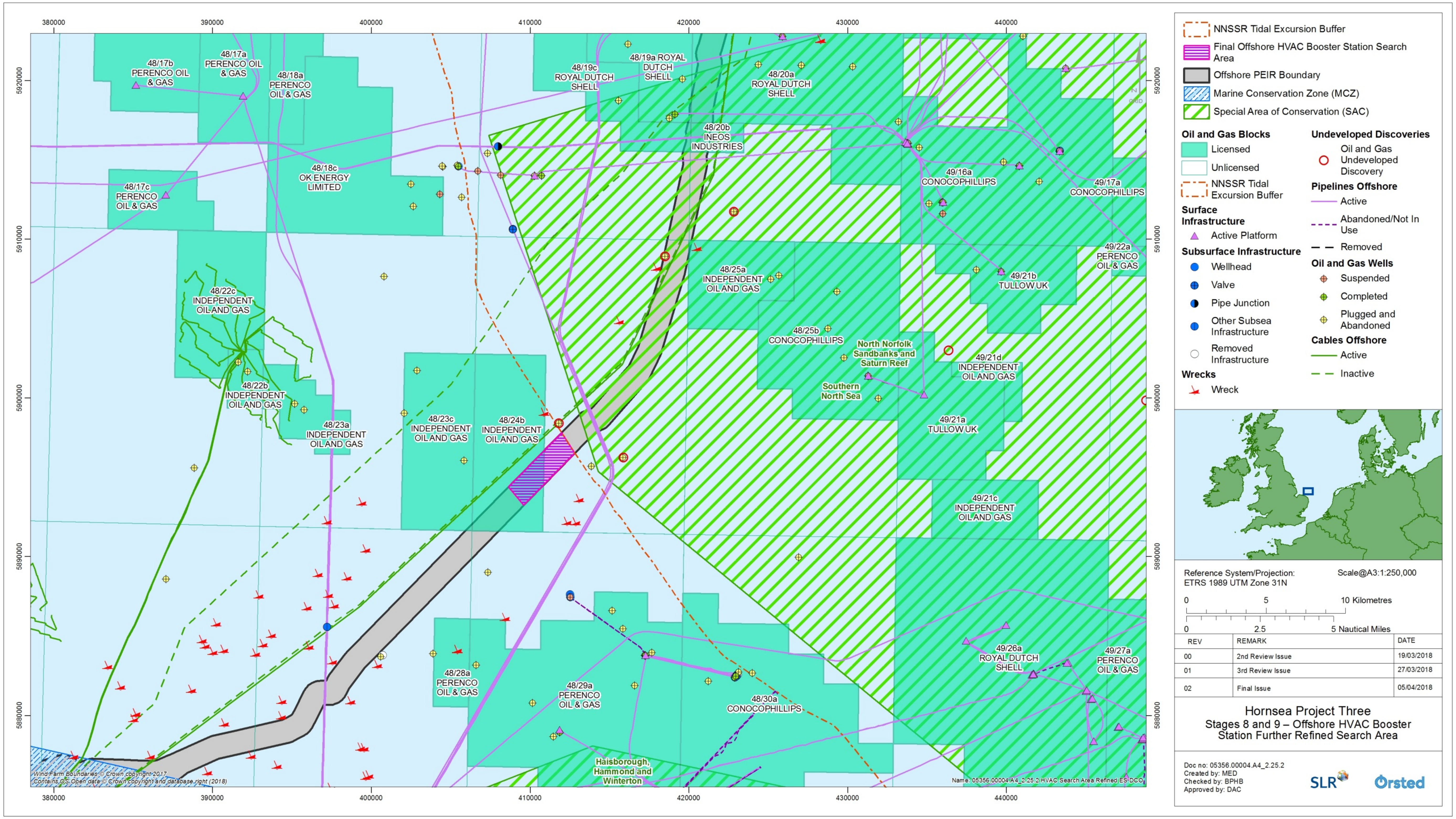


Figure 8.7: Stages 8 and 9 - Offshore HVAC booster station inner search area (using PEIR search area boundary).

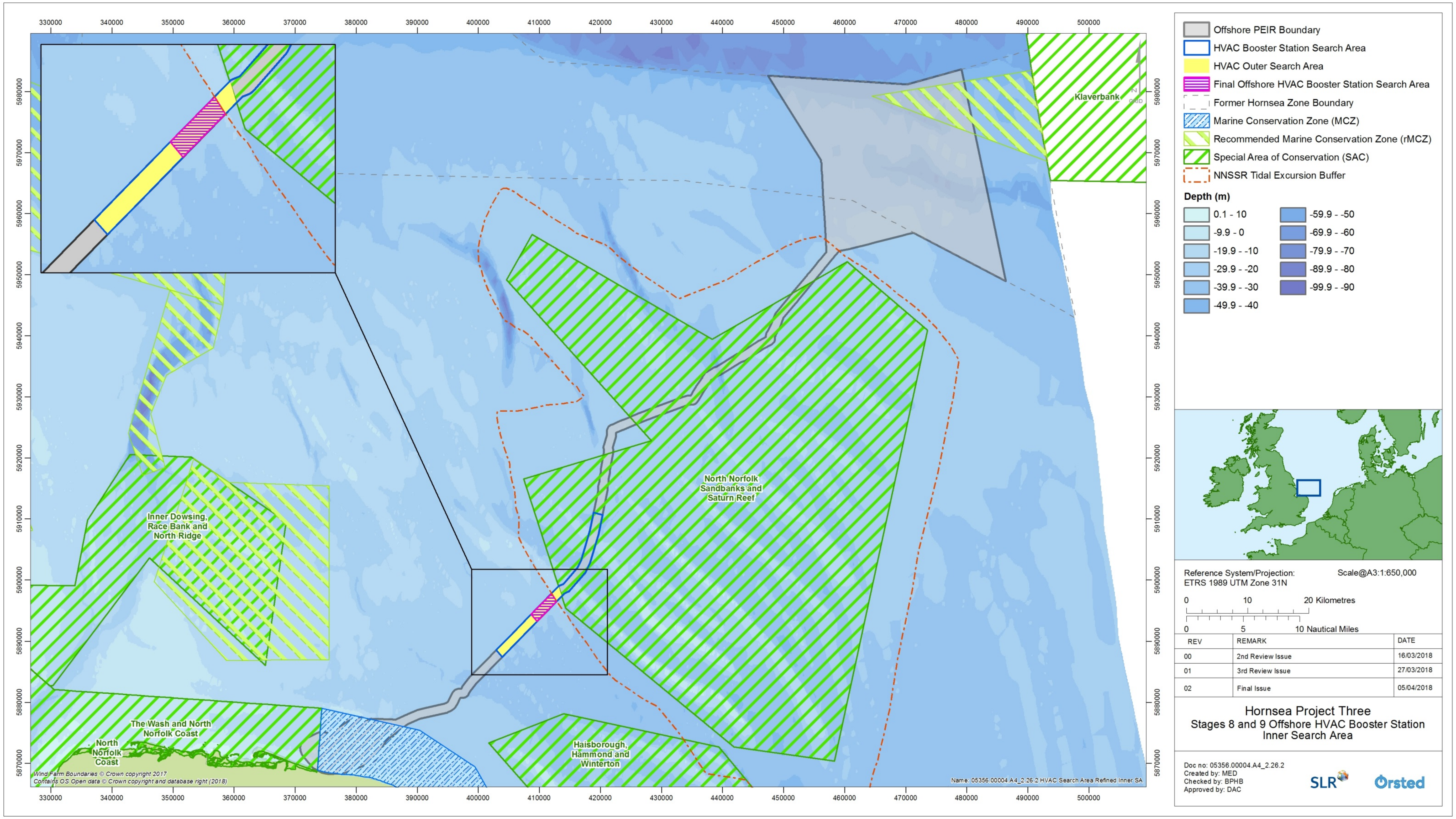


Figure 8.8: Stages 8 and 9 - Offshore HVAC booster station further refined search area (using PEIR search area boundary).

# 9. References

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