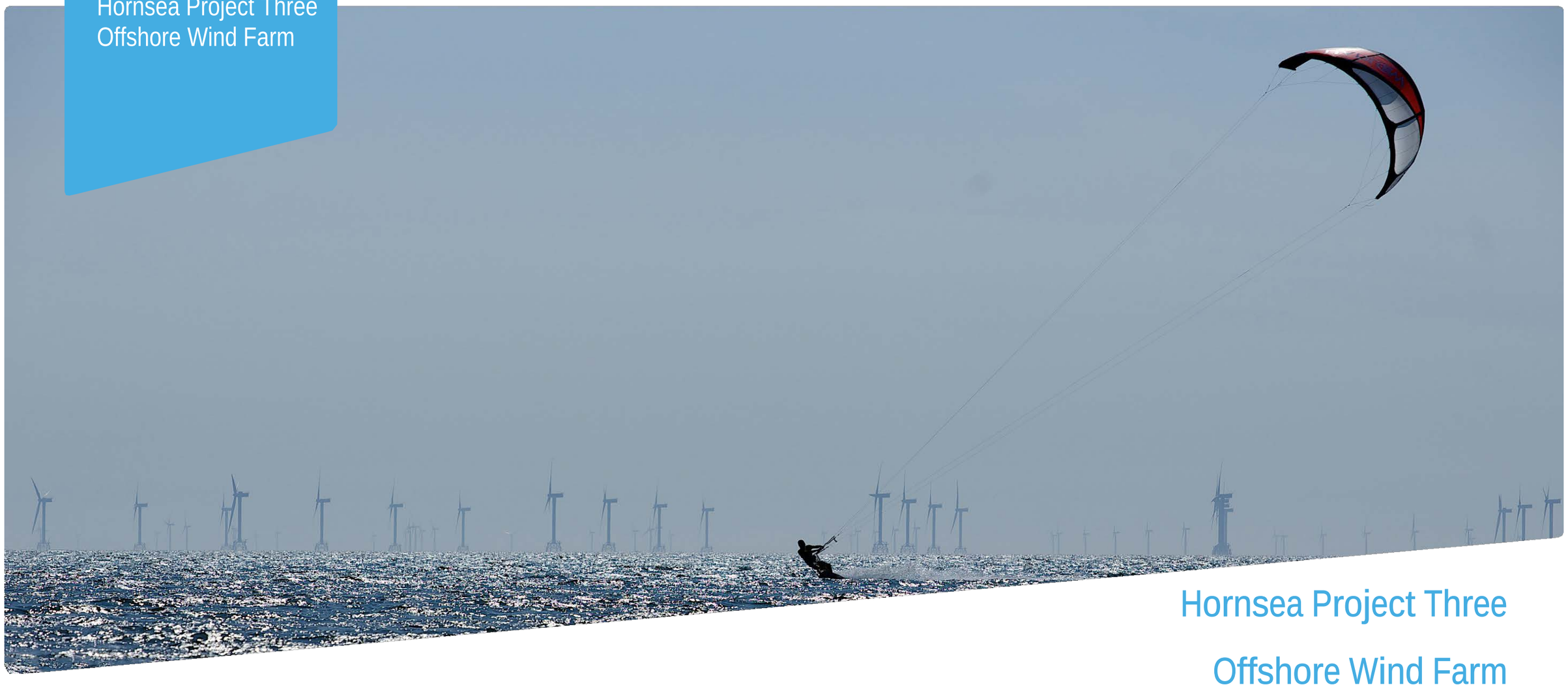
Hornsea Project Three
Offshore Wind Farm



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Offshore Wind Farm

Environmental Statement:
Volume 4, Annex 4.1 – Grid Connection and Refinement of the Cable Landfall (Stages 3-4)

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Hornsea 3
Offshore Wind Farm

Ørsted

Environmental Impact Assessment

Environmental Statement

Volume 4

Annex 4.1 – Grid Connection and Refinement of the Cable Landfall Hornsea Project Three (Stages 3-4)

Report Number: A6.4.4.1

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Acronyms

Acronym	Description
DBA	Desk Based Assessment
ECR	Export Cable Route
GIS	Geographical Information System
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MHWS	Mean High Water Springs
NGET	National Grid Electricity Transmissions
NNR	National Nature Reserve
PRoW	Public Right of Way
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest

Units

Unit	Description
GW	Gigawatts
km	Kilometre (length)
kV	kilovolts
m	Metre (length)

1. Introduction

1.1 Introduction and Purpose of the Annex

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 provides the background information and decision making involved in project development Stages 3 and 4. Note that volume 4, annex 4.2 Selection and Refinement of the Offshore ECR and HVAC Booster Station considers the offshore elements of Stage 4.

1.1.1.2 Stages 3 and 4 describe the selection of potential landfall Zones and the consideration of these in combination with information about offshore and onshore export cable routes (ECR) from the Hornsea Three Array offshore via those landfall zones to the connection point with the National Grid Electricity Transmissions (NGET).

1.2 Project Elements

1.2.1.1 Consideration of potential landfall zones was on the basis that the six marine cables come ashore in a 60 m wide permanent cable corridor to a landfall compound with transition joint bays to connect the marine and terrestrial export cables.

1.2.1.2 The strategic consideration of the onshore ECR as part of stage 4 was also based on a 60 m permanent terrestrial cable corridor but noting that a slightly wider working corridor (80 m) is required for construction purposes.

1.2.1.3 The analysis in this document also refers to the main alternatives considered and routing of the offshore cable and siting of the offshore HVAC booster station as described in the separate volume 4, annex 4.2: Selection and Refinement of the Offshore ECR and HVAC Booster Station.

2. Stage 3 - High Level Connection Options and Grid Connection Offer

2.1 Overview of Routeing approach

2.1.1.1 The identification of potential grid connection routes including Landfall Zones for Hornsea Three comprised a sequence of steps to identify the route between the start and end point for the connection. In this case the start point is the Hornsea Three offshore substation with the endpoint being a connection made to a location established with NGET.

2.1.1.2 As explained in Chapter 4, Stage 2, Ørsted (formerly DONG Energy), originally acquired the rights to develop Hornsea Three with an associated grid connection agreement of 2 GW at Walpole, just to the south-east of The Wash. However, further assessment of the array area identified potential within the array for a significantly greater capacity. In addition, the grid connection timing needed to be adjusted. As a result it was necessary to review the pre-existing grid connection agreement. Hornsea Three began discussions with NGET in 2016, with the objective of identifying potential grid connection locations for Hornsea Three's increased generating capacity and to match anticipated connection dates.

2.1.1.3 In the early stages of route selection (i.e. this Stage 3), the location of the final onshore grid connection was therefore unknown and could theoretically have been any point along the eastern coast to one of a number of NGET substations. One early route considered for the Hornsea Three ECR would be to have used the existing cable route corridor that was used for Hornsea One and Hornsea Two, providing a landfall in the vicinity of Grimsby with a grid connection at Killingholme. However at that initial stage, NGET indicated that the 400 kV substation at Killingholme had no additional capacity and that capacity north of Boston was unlikely in the connection timeframes required, (timeframes which, whilst delayed slightly, do not lead to a different conclusion on connection availability). Additionally, review by Ørsted also identified that there was insufficient room within the existing offshore cable corridor from Hornsea One and Hornsea Two to accommodate the additional electrical cable circuits that would be required for Hornsea Three and a corridor landing just south of Grimsby was therefore discounted from further consideration.

2.2 National Grid Electricity Transmissions Connection Offer

2.2.1.1 Early engagement with NGET identified that the potential connection locations under their consideration comprised the following six locations.

- Bicker Fen;
- Weston Marsh;
- Walpole;
- Necton;
- Norwich Main; and
- Eye.

2.2.1.2 Figure 2.1 presents a series of illustrative connection routes from the Hornsea Three array area to these potential substation connection points.

2.2.1.3 NGET's decision making and thus its connection offer takes into account technical, commercial, regulatory, environmental, and socio-economic aspects. An important element of this assessment is the cost that will be passed on to the consumer (the public and businesses) as a result of the works which will be required to ensure the network can accommodate the project. As part of the economic assessment, consideration is made of the total life cost of the connection – assessing both the capital costs for both onshore and offshore networks and projected operational costs to the onshore network (over a project's lifetime) to determine the most economic and efficient design option and connection location. Whilst a developer inputs into this process the eventual offer is determined by NGET.

2.2.1.4 During NGET's offer preparation an accepted connection offer to another developer meant that the connection point at Necton reached capacity, with no additional generation able to be connected. The Necton option was therefore discounted from further consideration.

2.2.1.5 The grid connection offer process concluded that the preferred option representing the most optimal design (economic, efficient & co-ordinated) considering all criteria (i.e. technical, cost, environmental and deliverability) was Norwich Main Substation. Hornsea Three was formally offered a grid connection to that substation on 14 July 2016 which was signed on 24 October 2016.

2.2.1.6 Further studies were then focussed on establishing the optimum route connection between the Hornsea Three offshore substation and the Norwich Main substation. These studies considered the effects arising from possible combinations of the route of the onshore ECR, offshore ECR and landfall. The first part of which is the identification of landfall options.

2.3 Landfall Identification

2.3.1 Guiding Principles

2.3.1.1 General guiding principles for landfall selection were that it provided:

- The shortest route to minimise impacts by 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, sought to mitigate impacts;
- Minimisation of disruption to populated areas thereby lowering effects; and
- For the accommodation of the range of connection technology sought within the design envelope, and excludes those options outwith the design envelope (i.e. ruling out overhead lines).

2.3.2 Define Landfall Study Area

2.3.2.1 The Landfall study area was defined by initially drawing a line at 90 degrees perpendicular to the straight line route between the connection end points (i.e. between the offshore substation and the Norwich Main substation). This was drawn on the basis that, based on previous experience, it was expected that a number of viable locations would be identified within the area encompassed and that locations further away from this would be discounted due to much greater connection distance. Should such viable locations not have been identified this stage would have been revisited and the search area widened.

2.3.2.2 As shown on Figure 2.2, this wider study area encompasses the North Norfolk Coast from approximately Kings Lynn in the west to Great Yarmouth in the east (circa 85 km of coastline).

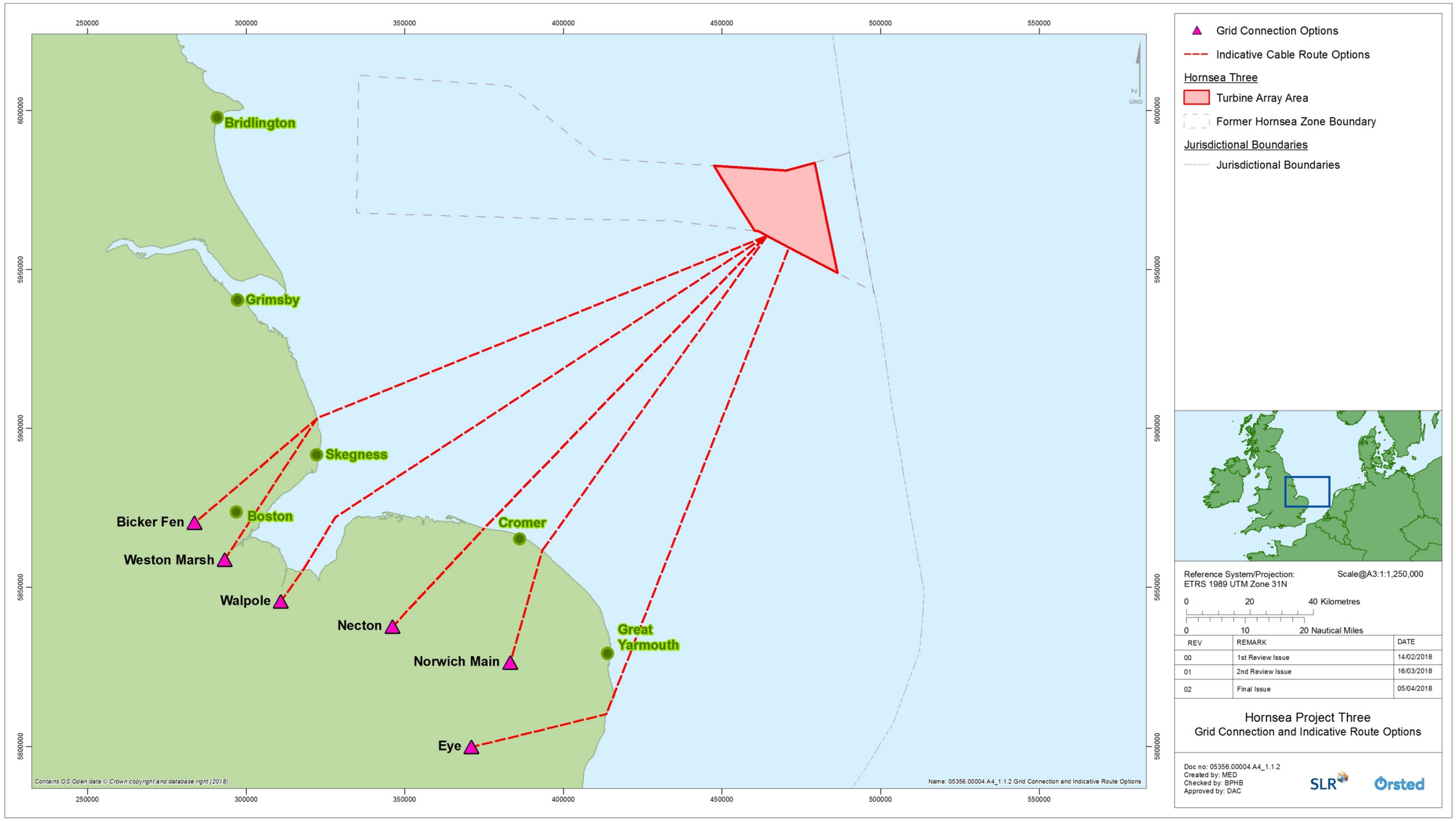

Figure 2.1: Grid Connection and Indicative Route Options.

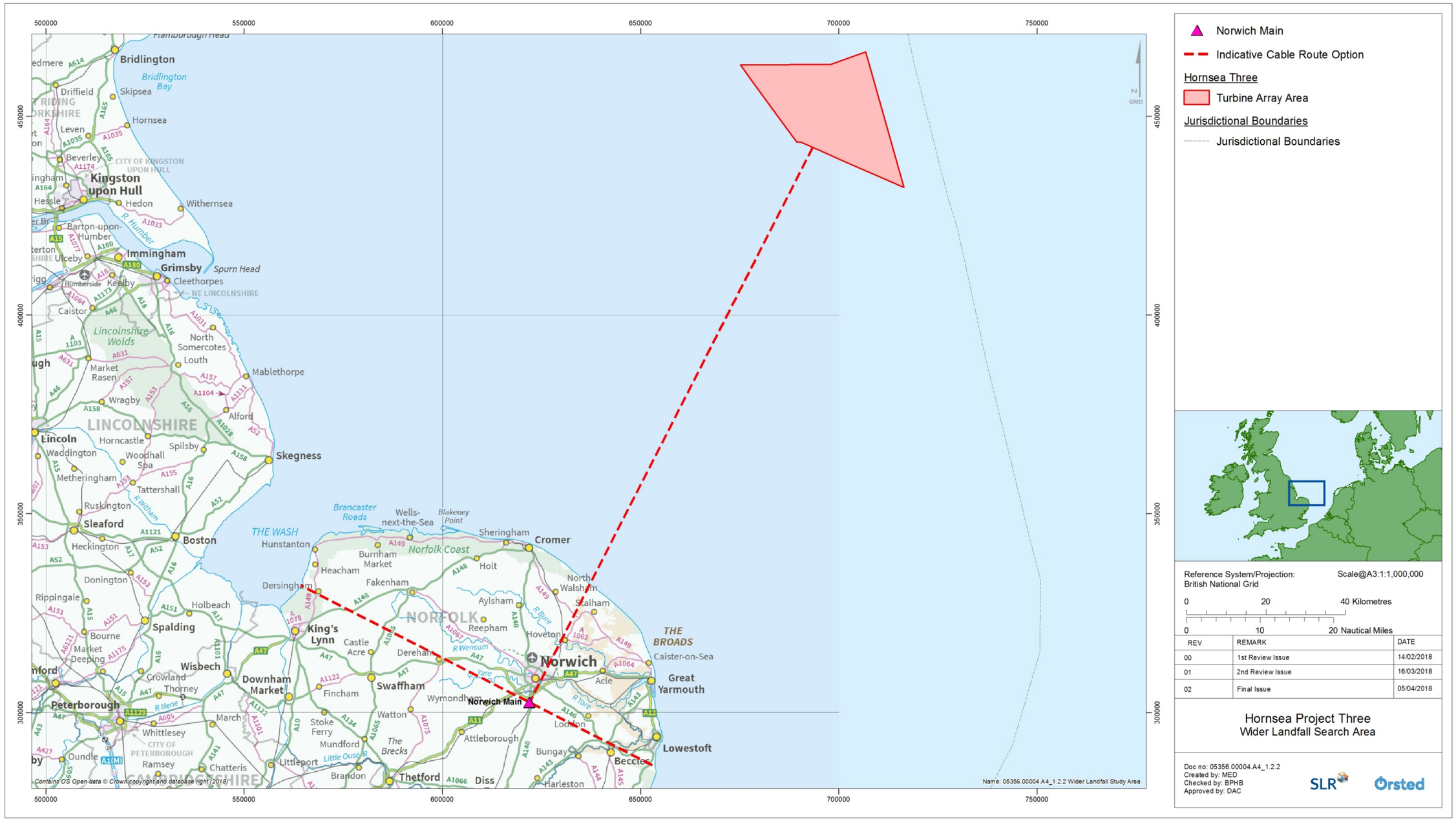

Figure 2.2: Wider Landfall Study Area.

2.4 Initial Landfall Assessment and Identification of Landfall Search Zones

2.4.1.1 The next stage in the identification of a suitable coastal landfall site was the delineation of high level zones for detailed Desk Based Assessment (DBA) within the wider study area. The delineation of these high level zones provided a basis for focussing more detailed analysis to aid further selection. It does not imply that all locations within the high level zone were considered viable landfalls.

2.4.1.2 Extensive areas of constraints to cable installation that precluded a viable connection route, or where a combination of factors substantially reduced the likely deliverability of a viable connection (even allowing for mitigation), were excluded where these were readily discernible from available data. This included features along the coastal strip as well as those close inland or close offshore which may be very difficult to avoid. At this stage of strategic consideration, not all of these factors provided absolute constraints and professional judgement was applied to inform whether potential constraints were likely to be able to be either: overcome through diversions at later stages of detailed route identification; mitigated through specific installation technology; or otherwise managed through mitigation of impacts. The factors considered were:

Avoidance of:

- High (>20 m cliffs), eroding or geo-morphologically active/unstable coastal cliffs;
- Large urban areas or where many dispersed properties meant works would be in close proximity to residential property;
- Registered Common Land;
- Land designated for nature conservation where possible unless technology selection or other mitigation would be effective or no other viable alternatives existed;
- Designated heritage assets unless technology selection or other mitigation would be effective;
- Land used for defence purposes;
- Running close to or adjacent to railway lines;
- Excessive permanent take of Class 1 Agricultural Land (noting that along cable routes restoration will allow continued agricultural use);
- Steep gradients/banked verges;
- Standing water and saltmarsh;
- Areas of ancient woodland habitats or other areas of woodland likely to have nature conservation interest where possible;
- Underground rock/solid substrates which increase cable laying and protection difficulties;
- Wind farm arrays; and
- Aggregate extraction areas.

Minimisation of:

- Third party interaction in terms of cable burial requirements;
- Minimise crossings of linear natural features and infrastructure, e.g. rail, road, water and oil and gas utilities and where possible, aim to cross these at 90°; and
- The amount of private land required;

Requirement for:

- Feasible transition jointing bay locations and cable pull-in;
- Suitable access for inspection and maintenance and foreshore vehicular access for construction; and
- Realistically achievable length of Horizontal Directional Drilling (HDD) (or similar technology) required to cross any of the sea defences and or rivers, railways and main roads with suitable working area to allow for drilling operations (if required);

2.4.1.3 Applying the above criteria with that professional judgement, led to the identification of five ‘landfall zones’ for further detailed investigation as shown on Figure 2.3.

2.4.1.4 These zones were:

- Zone 1 – Titchwell to Holkham;
- Zone 2 – Salthouse to Cromer;
- Zone 3 – Cromer to Mundesly (previously referred to as Overstrand to Sidestrand);
- Zone 4 – Broomholm to Waxham; (previously referred to as Happisburgh to Waxham); and
- Zone 5 – Heacham to Hunstanton.

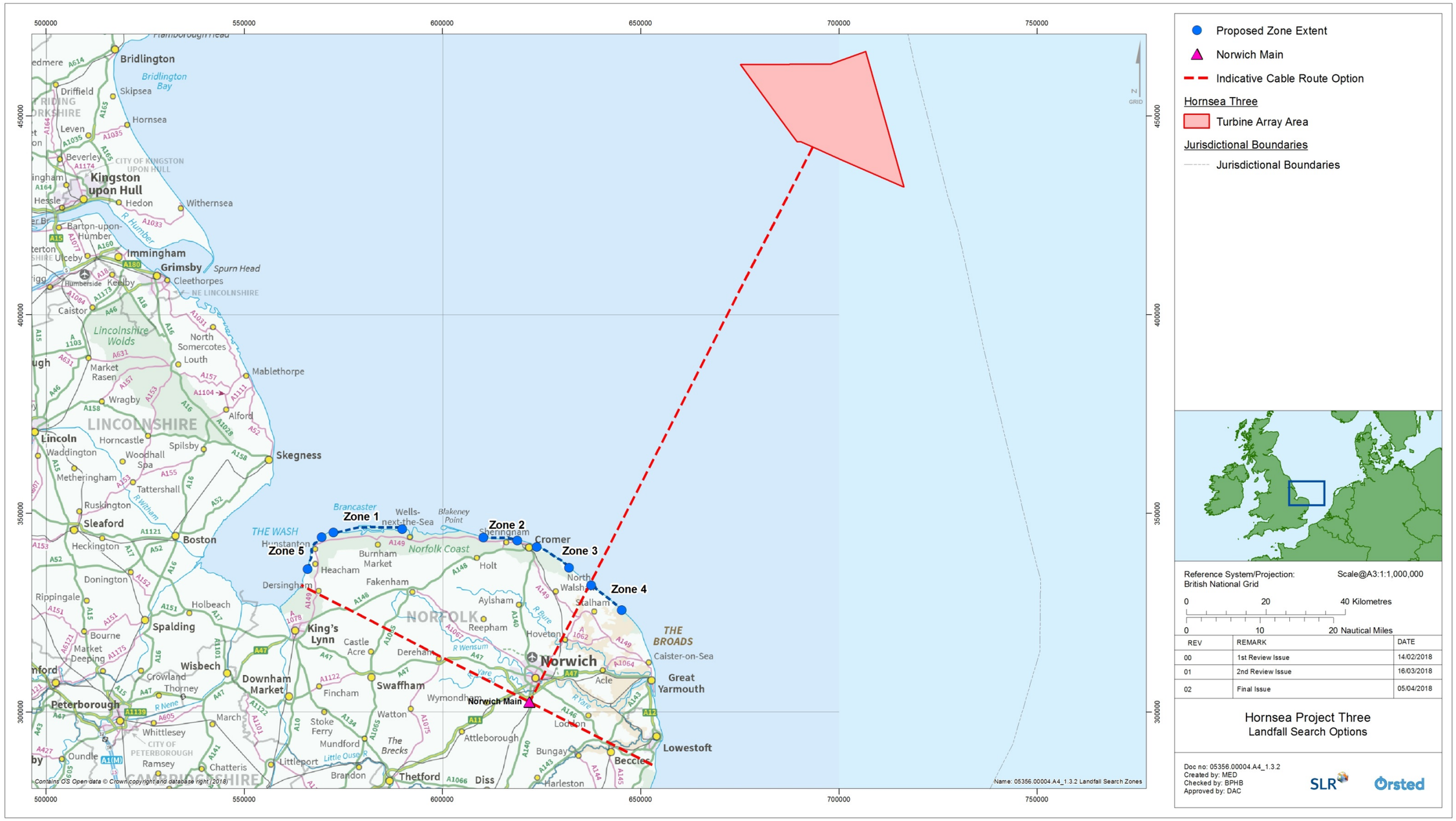

Figure 2.3: Landfall Search zones.

2.4.1.5 The main areas excluded from these broad zones, and the main reasons for that exclusion were as follows:

- South of Zone 4. This area presents a variety of constraints to successful cable routing near to the shore including Scroby Sands Wind Farm and a number of offshore Aggregate Areas. Additionally, along the shore line are the extensive urban areas of Great Yarmouth and Lowestoft. Avoidance of these constraints would require an extensive diversion of the cable route to the south. The increased level of effects and costs associated with such a diversion meant any alignment would perform poorly compared with other options and a landfall zone further south was therefore discounted from further consideration. This decision would have been revisited should subsequent studies have failed to identify a viable landfall option in Zones 1 to 5;
- Between Zones 3 and 4. There is a high concentration of built development in this area (e.g. Walcott, Bacton, Bacton Green, Paston) which provides little opportunity for a suitable landfall site;
- Between Zones 2 and 3. There is a high concentration of built development around Cromer which provides little opportunity for a suitable landfall site;
- Between Zones 1 and 2. An extensive assemblage of designations, saltmarshes and geomorphological features (e.g. Blakeney Point) are present where it was not considered that an acceptable installation technique could be identified. It is noted that such designations also extend into Zone 1 though, as the width of cable crossing required is in parts shorter than that in the area between zone 1 and 2, a precautionary approach to include Zone 1 was taken pending further consideration of the feasibility of installation via HDD techniques;
- Between Zones 1 and 5. A combination of the width of designations to be crossed (exceeding that considered viable for HDD techniques) and the distribution of scattered residential properties preclude use of this area; and
- West of Zone 5. The additional length of cable route and additional challenges of cable installation in the Wash were considered to lead to increased level of effects and costs meaning that any alignment would perform poorly compared with other options so were discounted from further consideration. This decision would have been revisited should subsequent studies fail to have identified a viable landfall option in Zones 1 to 5.

3. Stage 4 - Identification and Refinement of Coastal Landfall Options

3.1 Overview

3.1.1.1 Following the confirmation and acceptance of the grid connection to Norwich Main Substation and appraisal of landfall options (stage 3) a more detailed site selection process was undertaken to identify more specific project components comprising:

- Refinement and selection of one or more preferred landfall zones to be taken forward;
- Defining one (or more) broad offshore export cable corridor search areas (encompassing potential future HVAC booster station locations) between preferred landfall zone and offshore substation location; and
- Defining one (or more) broad onshore export cable corridor search areas (encompassing potential future HVAC booster station and onshore substation / Convertor Station locations) between preferred landfall zones and offshore substation location.

3.1.1.2 The intention of this stage was to establish alternatives with sufficient detail to enable meaningful engagement through Scoping and Phase 1.A consultation with the public, whilst retaining sufficient flexibility for iterative refinement through consultation feedback and acquisition of site specific information. The process for the selection of the preferred landfall zone(s) is described in the following paragraphs. This was an iterative process with refinement of landfall zones followed by offshore and onshore route appraisal then feeding back into a further refinement of the remaining landfall zones in Stage 5-7.

3.2 Definition of Landfall Areas within Landfall Zones

3.2.1.1 All five of the landfall zones were visited by a multi-disciplinary team of environmental and consenting specialists, construction and installation engineers and commercial managers to assess their viability from all perspectives e.g. technical, site and land access (including asset management) environmental and consents issues.

3.2.1.2 Prior to the site visits each zone was mapped to identify any technical or consenting risks and identify any constraint free areas or less constrained areas that could be a focus for site visits. The key constraints considered for landfall site selection were as set out in paragraph 2.4.1.2 above along with a consideration of the following technical, consenting and cost implications:

3.2.2 Technical constraints:

- Nearshore and beach profile, & coastal geology and geomorphology e.g. distance to 15m depth contour for boat access ; detrimental beach and seabed geology and sedimentology that could beach a vessel or bury/erode cables; presence of cliffs or eroding coast;
- Proximity to existing infrastructure e.g. existing cables, pipelines, outfalls, sub surface utilities and sea defences;
- Suitable access for construction vehicles and extent of suitable working/construction areas at HDD locations; and
- Proximity to residential areas which would limit working area or could potentially cause disturbance or require restrictive limits on construction activities.

3.2.3 Consenting constraints:

- Proximity to designated sites of conservation interest or important rare features such as Annex 1 habitat (reef or sandbank); areas of commercial fishery importance (cockle/mussle beds etc);
- Proximity to existing infrastructure (as specified above);
- Interaction with recreation such as busy beaches, car parks or right of way/long distance trails; and
- Proximity to residential areas (as specified above).

3.2.4 Commercial constraints:

- Land acquisition requirements;
- Construction costs for landfall works; and
- Cost implications for offshore and onshore cable length.

3.2.4.1 An assessment of each potential landfall within each of the five zones was undertaken to identify any viable options or targeted areas for detailed site visits/appraisal and informed further selection of preferred landfall zones to be taken forward for consideration in combination with onshore and offshore ECRs.

3.3 Landfall Zone Assessments

3.3.1 Zone 1 Initial Assessment Results

3.3.1.1 Two areas within Zone 1 were identified as likely to provide the best balance of the above criteria. These were short areas of the coast just to the north of Titchwell (to the western end of the zone) and an area just to the north of the Holkham Reserve (to the east of the zone), both of which also provided potential access points to the beach. The locations are shown on Figure 3.1.

3.3.1.2 The main reasons for excluding other areas within Zone 1 were:

- The extent of registered common land;
- The extent of environmental designations; and
- Eroding nature of parts of the coastline and complexity of geomorphological features (e.g. Scolt Head Island).

3.3.1.3 The Titchwell and Holkham areas themselves present various constraints as assessed by a multi-disciplinary team.

Titchwell

- Access for construction vehicles was poor with the road (A149) some way from the beach c.1.5 km. Ground conditions would be difficult being marshy and wet (saltmarsh);
- Nearshore bathymetry is uncertain with shallow and variable water depths on what appeared to be a geomorphically active coastal area. A long inter-tidal HDD would likely be required >1km long;
- The land is on the boundary of internationally designated Special Area of Conservation (SAC) and Special Protection Area (SPA) designations and is a sensitive bird area, with a number of designations including: Holmes Dune National Nature Reserve (NNR); Royal Society for the Protection of Birds (RSPB) Titchwell Marsh; and Scolt Head Island NNR. Blue Mussel beds were present to the north and east of the potential landfall zone;
- There were land acquisition concerns, with the area spatially constrained by National Trust and Common Land; and
- The construction costs are increased due to HDD, cable length and access improvement requirements.

Holkam

- Access would likely be via a Public Right of Way (PRoW) and Car Park with a high tourist usage and is Public Open Space;
- Nearshore bathymetry was uncertain with shallow and variable water depths on what appeared to be a geomorphically active coastal area. A long (>1 km) potentially multi-phase HDD would be required, under a forested area adjacent to fields, and then under the coastal dunes; and
- The land is on the boundary of internationally designated SAC and SPA designations and is a highly sensitive habitat, with a number of environmental designations e.g. nearby Scolt Head Island NNR and Holkham reserve. Valuable habitat mosaic of dunes, machair and mixed woodland.

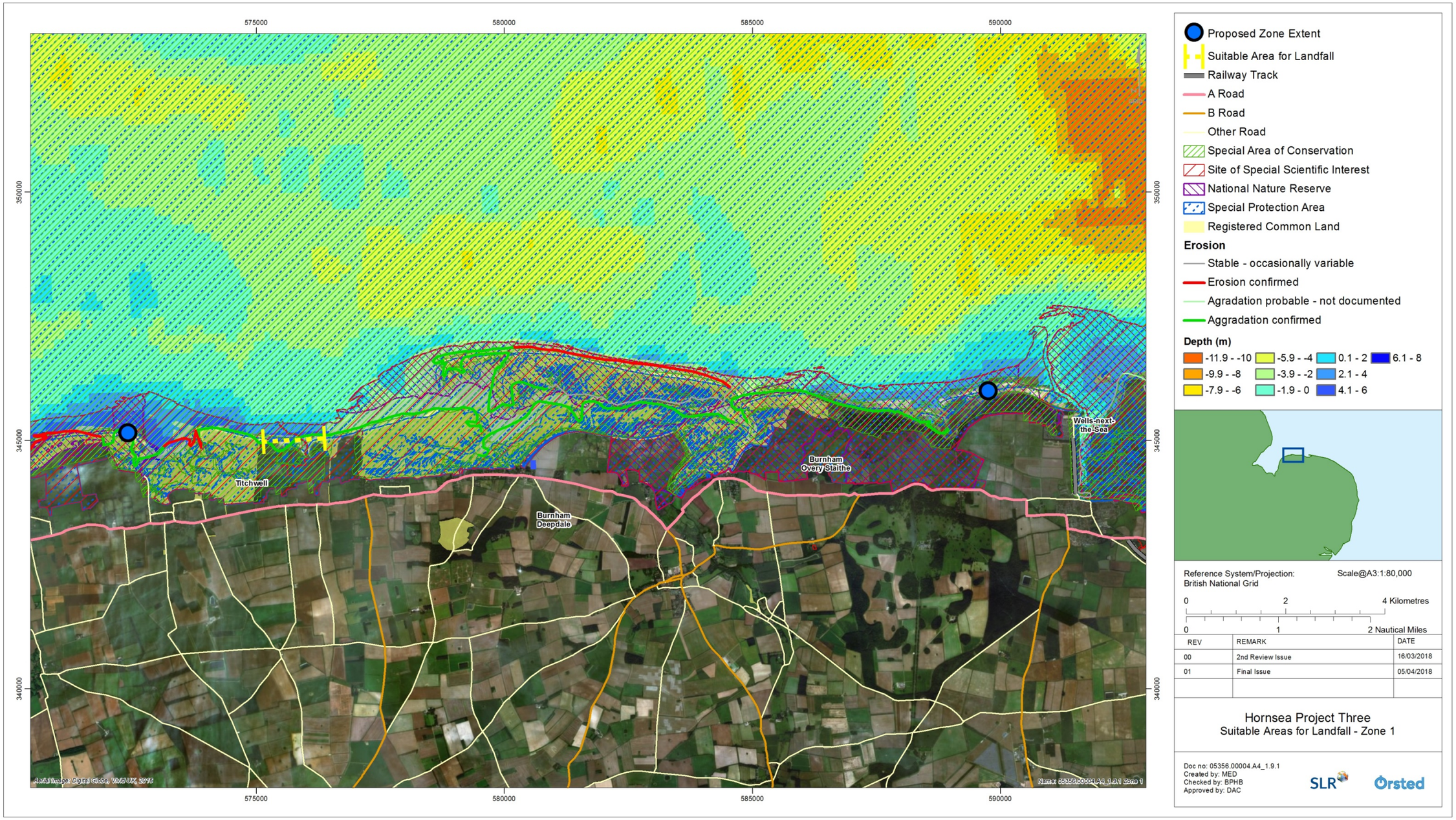

Figure 3.1: Aerial Photograph of Landfall Zone 1.

3.3.2 Zone 2 Initial Assessment Results

3.3.2.1 Within Zone 2 one area was identified as likely to provide the best balance of the above criteria. This was the coastal stretch between Weybourne and Salthouse to the west of the zone. The location is shown on the aerial photograph as Figure 3.2 below.

3.3.2.2 The main reasons for excluding other areas within Zone 2 were:

- The extent of urban area to the eastern end notably in Sheringham and West Runton; and
- The presence of higher and eroding cliffs presenting construction challenges.

3.3.2.3 In contrast the identified landfall area has good access, no sea defences and sections of low coastal cliffs and was not otherwise spatially constrained. The presence of existing infrastructure and cable landing points also confirmed it was potentially suitable. The site nonetheless presents various constraints as assessed by a multi-disciplinary team.

3.3.2.4 These include:

- Unknown coastal geology and geomorphology in places;
- The existence of the Sheringham to Holt railway line which the cable would need to cross when heading south;
- Access from A149 road to landfall which would be circa 700 m;
- Proximity to the Dudgeon and Sherringham Shoal Offshore Wind Farm offshore and onshore cable routing;
- Land acquisition constraints with National Trust land to the east; and
- Potential construction costs subject to the need for HDD and proximity of other cables as well as the overall cable length to the landfall.

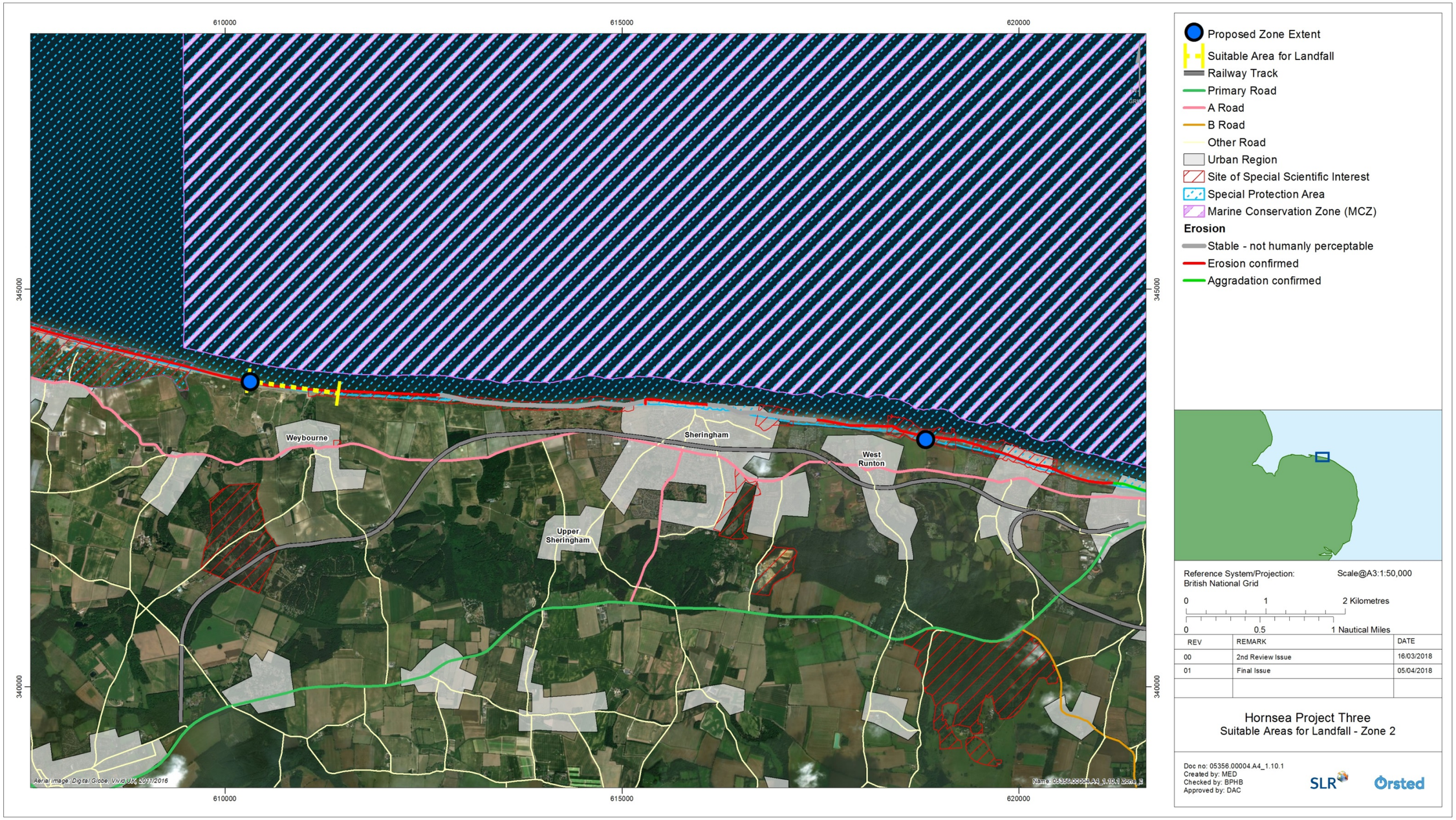

Figure 3.2: Aerial Photograph of Landfall Zone 2.

3.3.3 Zone 3 Initial Assessment Results

3.3.3.1 Landfall Zone 3 is shown in Figure 3.3 below. Following site visits no suitable areas for landfall were identified within Zone 3.

3.3.3.2 The main reasons for excluding all areas within Zone 3 were the combination of:

- Urban areas including Overstrand, Sidestrand, Trimingham and Mundesley
- Very high restrictive cliff features >40 m high and associated restricted vehicle access to the beach. HDD through such cliffs would be technically challenging. Thermal cable issues are also a significant constraint'(caused by the depth of HDD meaning that heat cannot be dissipated away from the cable easily hence increasing transmission losses). Photo 1 shows the nature of the cliffs southeast of Sidestrand.
- Cliffs actively eroding in some locations and numerous costal defences, due to eroding coast with groynes present.

Photo 1: Cliffs south-east of Sidestrand.

3.3.4 Zone 4 Initial Assessment Results

3.3.4.1 Landfall Zone 4 is shown in Figure 3.4 below. Within Zone 4, two areas were identified as likely to provide the best balance of the criteria identified above. One lies to the north of Cart Gap to either side of Happisburgh, and the other between Eccles on Sea and Waxham.

3.3.4.2 The main reasons for excluding other areas within Zone 4 were:

- The presence of various urban areas including Happisburgh, Eccles on Sea and Sea Palling; and
- The presence of higher cliffs presenting significant construction challenges (see paragraph 3.3.3.2).

3.3.4.3 In contrast the two areas identified were, on balance, considered to have good access to the foreshore, have areas without sea defences and include stretches of low coastal cliffs which are not actively eroding and in general were not spatially constrained.

3.3.4.4 The main remaining constraint to these sites, as assessed by a multi-disciplinary team are the multiple pipeline connections into the Bacton gas terminal which lies just to the north necessitating multiple crossings by the offshore ECR between the offshore substation and this landing Zone.

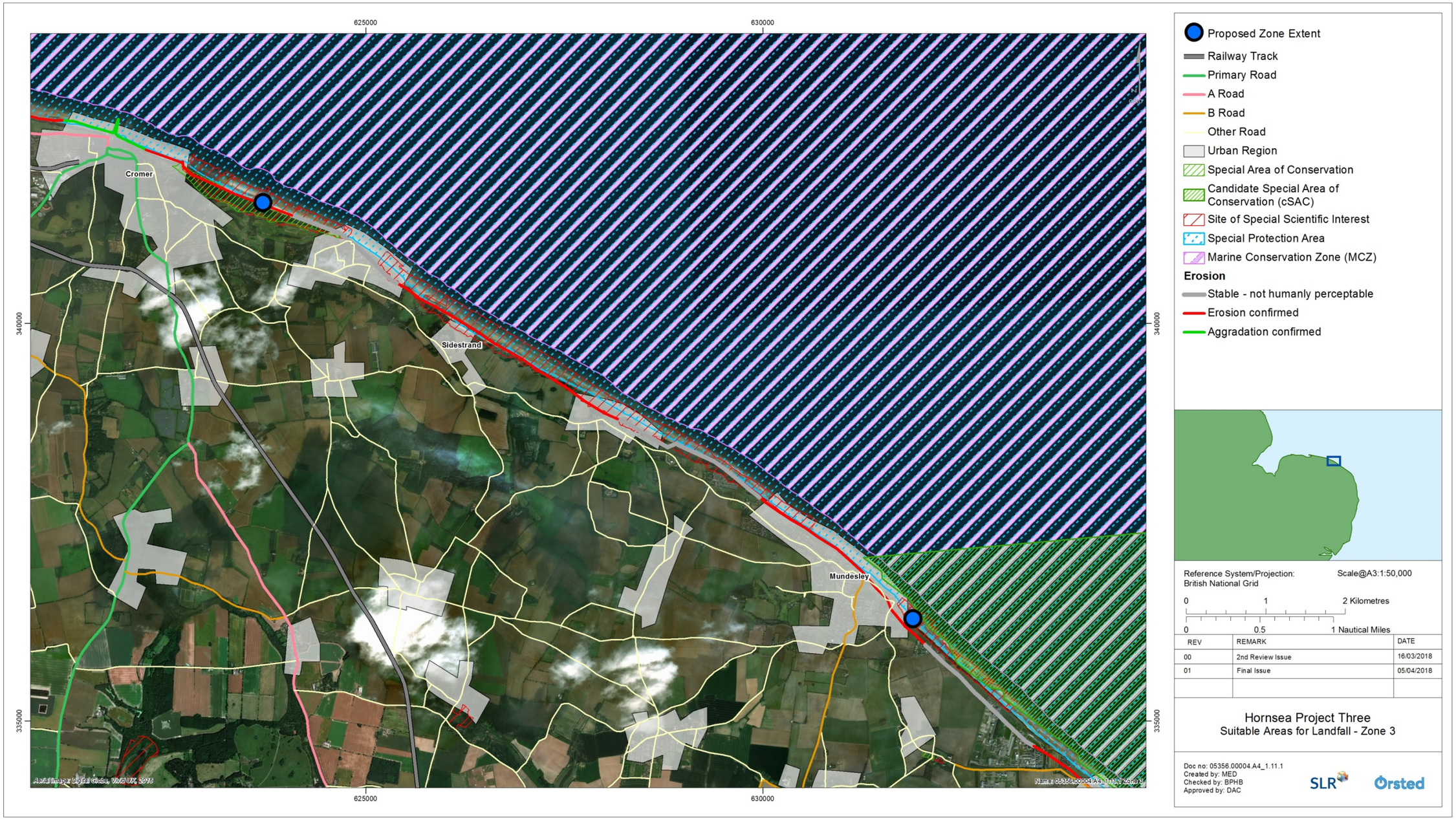

Figure 3.3: Aerial Photograph of Zone 3.

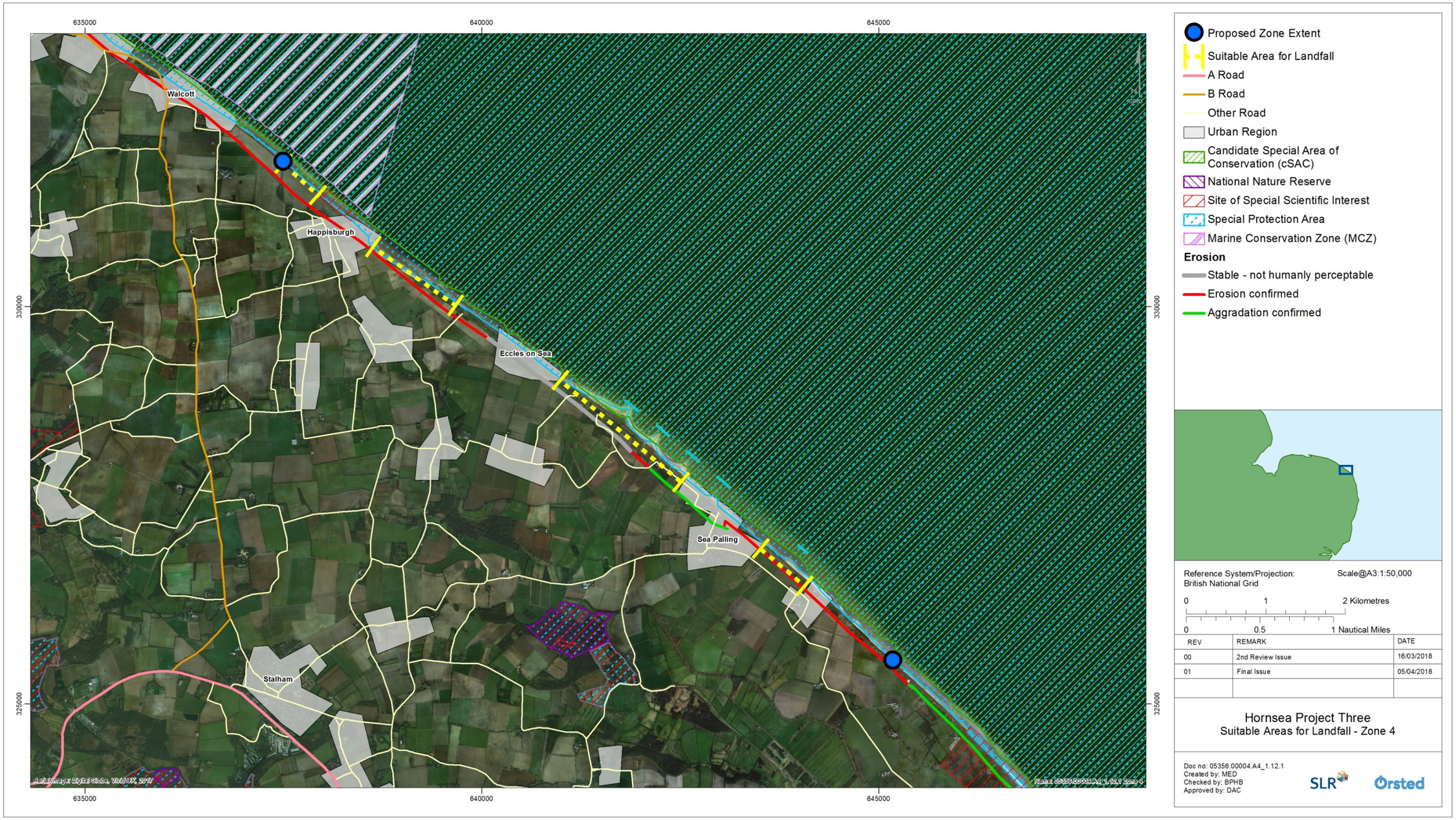

Figure 3.4: Aerial Photograph of Zone 4.

3.3.5 Zone 5 Initial Assessment Results

3.3.5.1 Landfall Zone 5 is shown on Photo 2 and in Figure 3.5 below. The northern end of the zone from the boundary of the Cliff Top car park at the northern edge of Hunstanton to the northern end of Hunstanton Golf Links at Holme was identified for investigation for Zone 5.

3.3.5.2 The main reasons for excluding locations further south from this were:

- the presence of residential properties in Hunstanton and Heacham and extensive caravan parks; and
- increased route length (at additional cost) through Site of Special Scientific Interest (SSSI) / Ramsar sites of the Wash with no substantive benefit compared with the more northern location in the zone.

3.3.5.3 The area included near Holme has relatively good vehicular access, the absence of sea defences and a wide foreshore. Nonetheless the following key constraints to development were assessed by a multi-disciplinary team:

- Access to the foreshore from the car park to the south was possible via the creation of an access from the car park via low cliffs (~5-8 m), existing access at the RNLI Hunstanton Lifeboat Station or access at Holme via the golf course. The car park access to the foreshore is across the Hunstanton Cliffs SSSI.
- There were land acquisition concerns, with some potential spatial constraints to the north of the car park with low dunes, holiday huts and golf course present along with common land also present to the north at Holme;
- The overall distance (and thus construction costs) to Norwich Main NGET substation is approximately 30% longer compared with Zone options 2, 3 and 4; and
- Highly variable nearshore shallow bathymetry, requiring long and complex intertidal works in an area of complex geomorphology.

Photo 2: Illustrative photo of Zone 5, Hunstanton Cliff.

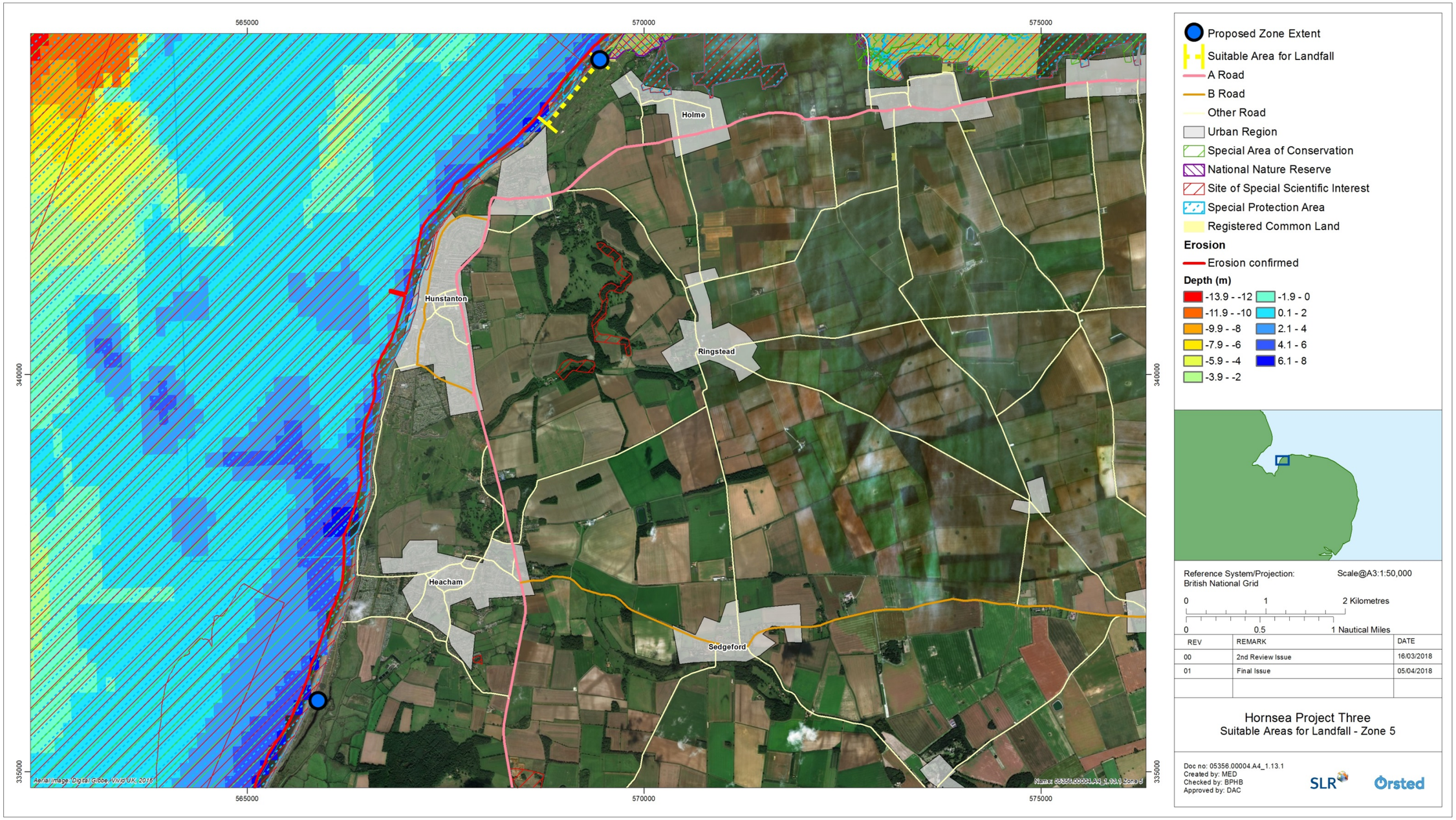

Figure 3.5: Aerial Photograph of Zone 5.

3.4 Refinement of coastal landfall options – Initial Zone Assessment Conclusions

3.4.1.1 The high level assessment of landfall zones (section 3.3 above) concluded that no technically viable landfall zone was available in Zone 3 due to the high cliffs. As such this Zone was discounted from further consideration.

3.4.1.2 Areas within each of the other Zones have the potential to provide a landfall location but all present different combinations and levels of technical, consenting and commercial risk. Areas within Zones 1 and 5 were identified as being significantly more technically challenging than those areas in Zones 2 and 4 due to limited foreshore access and highly variable nearshore shallow bathymetry, requiring long and complex intertidal works. Using either of Zones 1 and 5 would also substantially increase the overall ECR length and therefore reduce the economic efficiency of both these alternatives compared with areas within Zones 2 and 4. Areas within Zones 2 and 4 also face a number of constraints but none are considered to prevent consideration of the zones through more detailed study.

3.4.1.3 It was therefore recommended that Landfall areas within Zones 1 and 5 were discounted from further consideration and that Landfall areas within Zones 2 and 4 were taken forward for further detailed consideration. Final selection being made in light of the combination of effects arising from both onshore and offshore ECRs in combination with effects associated with Landfall Zones 2 and 4.

3.5 Onshore Cable Corridor Search Area

3.5.1 Overview

3.5.1.1 The overall comparison of ECR options considered the combination of effects arising from the landfall and both onshore and offshore ECRs. This section provides an assessment of the viability of potential connection corridors from Landfall Zones 2 and 4 to the Norwich Main Substation.

3.5.2 Project elements

3.5.2.1 The construction elements that would ultimately be required comprise:

- A 60 m wide permanent cable corridor widened to 80 m for construction;
- Transition Joint Bays above mean High Water Springs (MHWS), to connect the marine and terrestrial export cables;
- A 2.5 ha plus associated working area within (approximately) 10 km of the coast for the potential HVAC booster station;
- Cable jointing bays, and link boxes at intervals along the cable corridor (approximately 1 per km);
- Temporary cable route construction compounds;
- Temporary major crossing construction compounds;
- Temporary construction access roads; and
- Temporary cable corridor haul roads.

3.5.3 Defining the Search Area

3.5.3.1 The connection requires a new onshore HVAC substation / High Voltage Direct Current (HVDC) converter station and potentially an onshore HVAC booster station. The location of the HVAC substation / HVDC converter station will be in proximity to the NGET substation. As such, siting of this was influenced by local factors around the NGET substation and was not therefore considered to be a determinant for landfall / cable routeing considerations at this strategic stage. Similarly, whilst a HVAC booster station close to the landfall may potentially be needed there was sufficient flexibility for the location of this to benefit from existing landform and vegetation screening to allow this to be determined after identification of the preferred corridor. As such again it was not considered a determining factor for landfall / cable routeing considerations at this strategic stage.

3.5.3.2 The onshore search areas were developed on the basis of making landfall at either Zone 2 or Zone 4 and then an onshore ECR to a grid connection at Norwich Main substation. The purpose of this stage of consideration was not to establish a specific route but to establish that within a general corridor there were no insurmountable barriers to cable installation to allow comparison of strategic options. For this purpose, based on past experience on other projects, a general corridor of approximately 5 km wide was considered sufficient to allow for routeing around the majority of constraints, though some modifications to this were made as noted in the paragraph below. To establish the general corridors the main considerations were to identify the most direct route possible and to avoid developed areas (housing, commercial land etc.) where possible. On this basis the connection from Landfall Zone 2 would be routed to the west of Norwich. A route from Zone 2 passing to the east of Norwich would add substantially to the cable distance, require routeing through the Norfolk Broads National Park and therefore generally increase the level of environmental effects and construction costs. As there were no insurmountable routeing considerations for a route to the west, the route from Zone 2 to the east of Norwich was discounted from further consideration. Applying the same approach to the connection from Landfall Zone 4 would tend to imply a route to the south of Norwich should be taken forward, however in this case the need for such a route to unavoidably cross the Norfolk Broads National Park suggested that a longer and more costly route may potentially be justified when balanced against the potential effects on the National Park and therefore routeing either to the north or south of Norwich from Zone 4 should be considered.

3.5.3.3 The onshore search areas were intended to provide areas within which the most direct onshore routes possible between the two landfall zones and Norwich Main substation could be identified, with opportunities to avoid sensitive sites, environmental constraints, and major crossings. An area between the two landfall zones roughly between Sheringham and Wallcott, extending inland to a point near Felthorpe, was excluded from the search area on the basis any future cable routes within that area would represent a significant deviation from the most direct options available. The City of Norwich was excluded from the search area on the basis that the sufficient width of land would not be available to the project within the city boundary, any construction works within the city would cause significant disruption and the landownership and commercial considerations in that area would be too complex during all phases of the project. The general corridors were also widened from Zone 4 to give additional flexibility to potentially route around the Norfolk Broads National Park and substantial National Nature Reserves and also around all sides of Norwich in light of the additional concentration of infrastructure and built development that was present.

3.5.3.4 This resulted in a larger search area associated with potential landfall Zone 4 than Zone 2 as depicted on Figure 3.6.

3.5.4 Constraints and Appraisal Criteria

3.5.4.1 The main constraints to onshore cable routeing considered within these search areas were: ecology; nature conservation designations; landscape designations; tourism and recreation; cultural heritage assets; the presence of 'fixed' assets such as infrastructure (roads, railways, rivers); and land uses (settlements, commercial development, housing, surface water bodies, woodland).

3.5.4.2 The appraisal criteria applied in the assessment are therefore the extent to which interactions with these constraints are avoided and, where not avoided, the extent of residual interaction.

3.5.4.3 The onshore cable corridor search area was explored at a high level using Geographical Information Systems (GIS) and desk-based studies (including review of aerial photography), taking account of the same guiding principles as set out in section 2.3 and those constraints described above. Consideration was given as to the potential for any impediment to either search area (from Zone 2 and 4) being able to support the construction elements as described above.

3.5.4.4 Figure 3.7 to Figure 3.10 show the presence of constraint features within the onshore ECR search areas from Zone 2 and Zone 4.

3.5.5 Zone 2 General Corridor Analysis

3.5.5.1 A review of Figure 3.7 to Figure 3.10 shows that:

- The Zone 2 corridor contained a number of heritage conservation areas, historic Parks and Gardens and a large number of listed buildings. Whilst some construction stage effects may occur, routeing was expected to be able to avoid direct effects.
- With the exception of the AONB adjacent to the Landfall zone the remainder of the route was free from landscape designations. Long term effects on the AONB were expected to be reduced by adoption of cable technology.
- There were few ecologically designated or ecologically important areas and those that were present (SSSI and Ancient woodland) can be readily routed around or, as in the case of the River Wensum SSSI which the corridor crosses, were likely to be capable of being acceptably crossed with mitigation.
- Crossings of a number of rail lines and roads were unavoidable but can typically be achieved at 90 degree angles without undue diversion.
- A number of small urban areas (towns and villages) are dispersed along the Zone 2 general corridor though not in such proximity or density to overly constrain routeing; and
- Onshore connection length expected to be approximately 50 km.

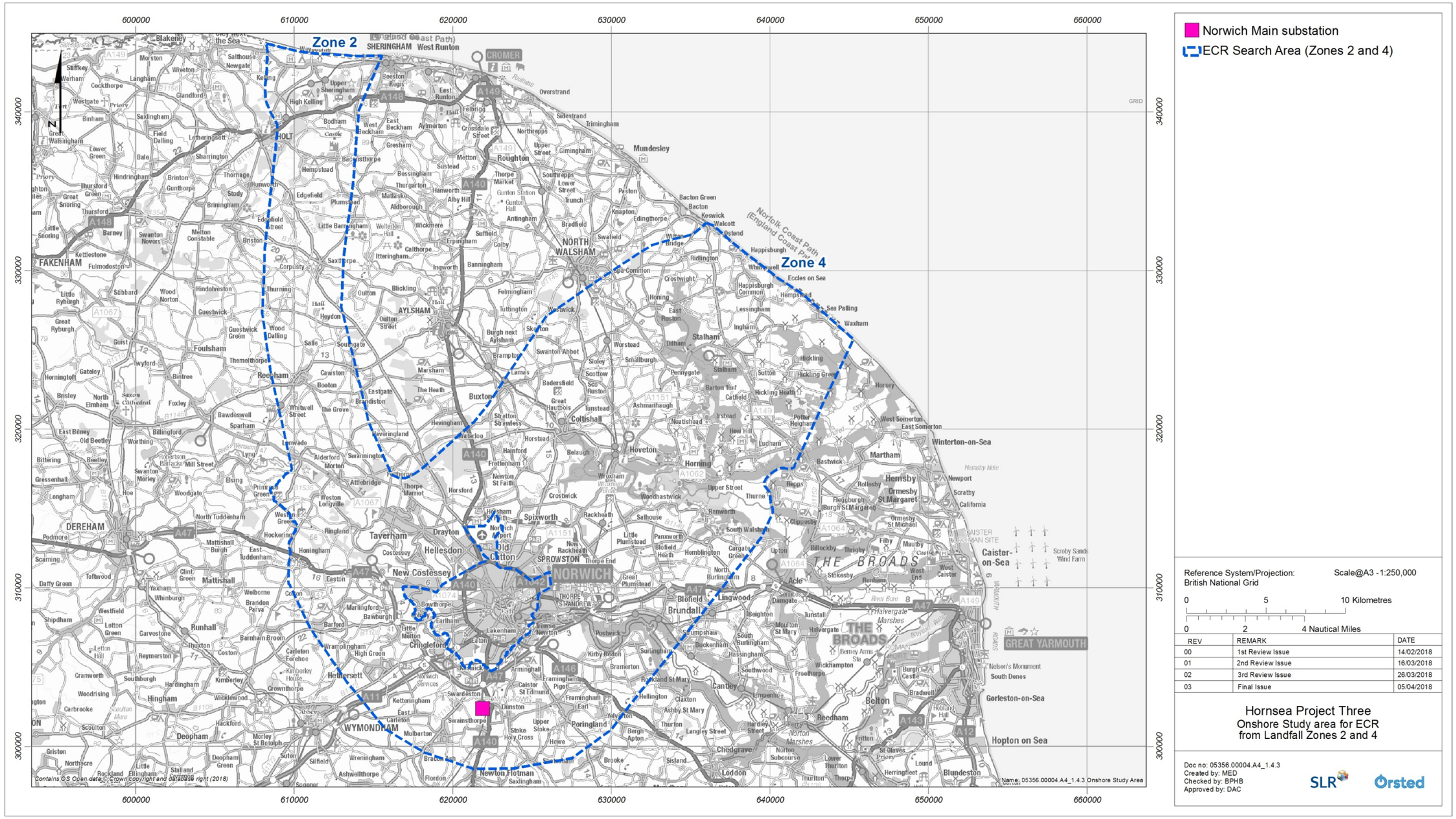

Figure 3.6: Onshore Study area for ECR from Landfall Zones 2 and 4.

Figure 3.7: Heritage Designations within the ECR Search area.

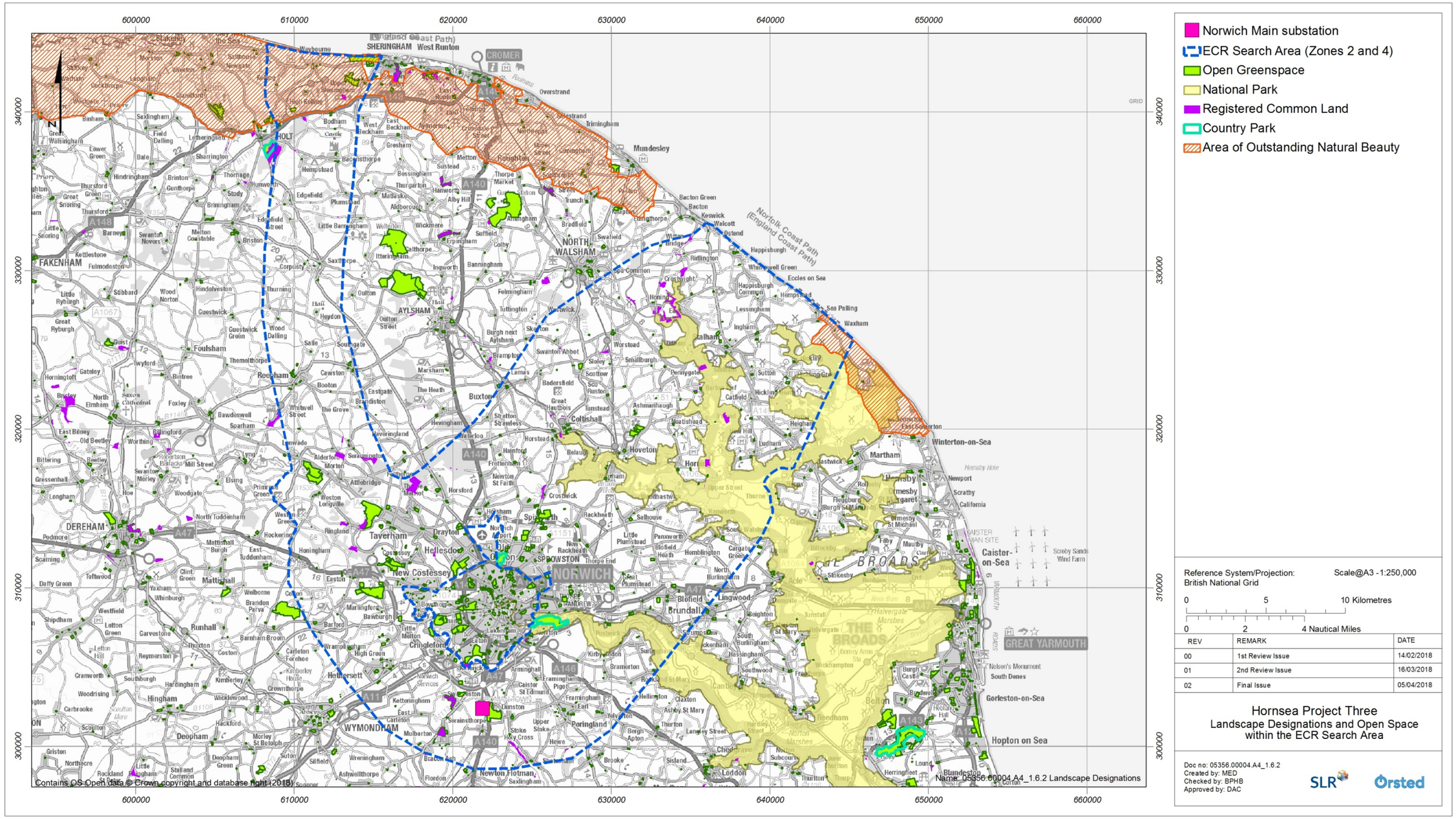

Figure 3.8: Landscape Designations and Open Space within the ECR Search Area.

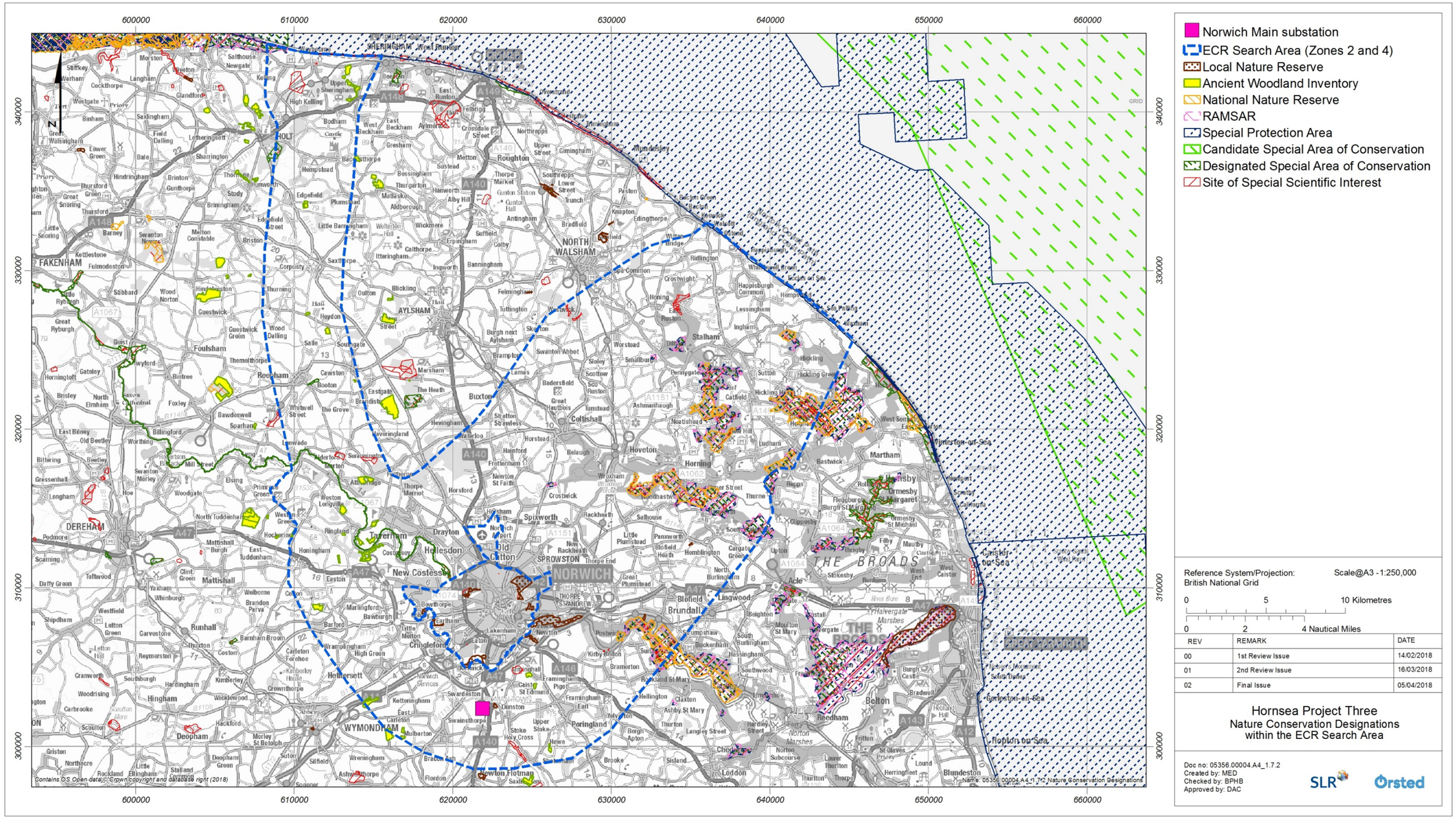

Figure 3.9: Nature Conservation Designations within the ECR Search Area.

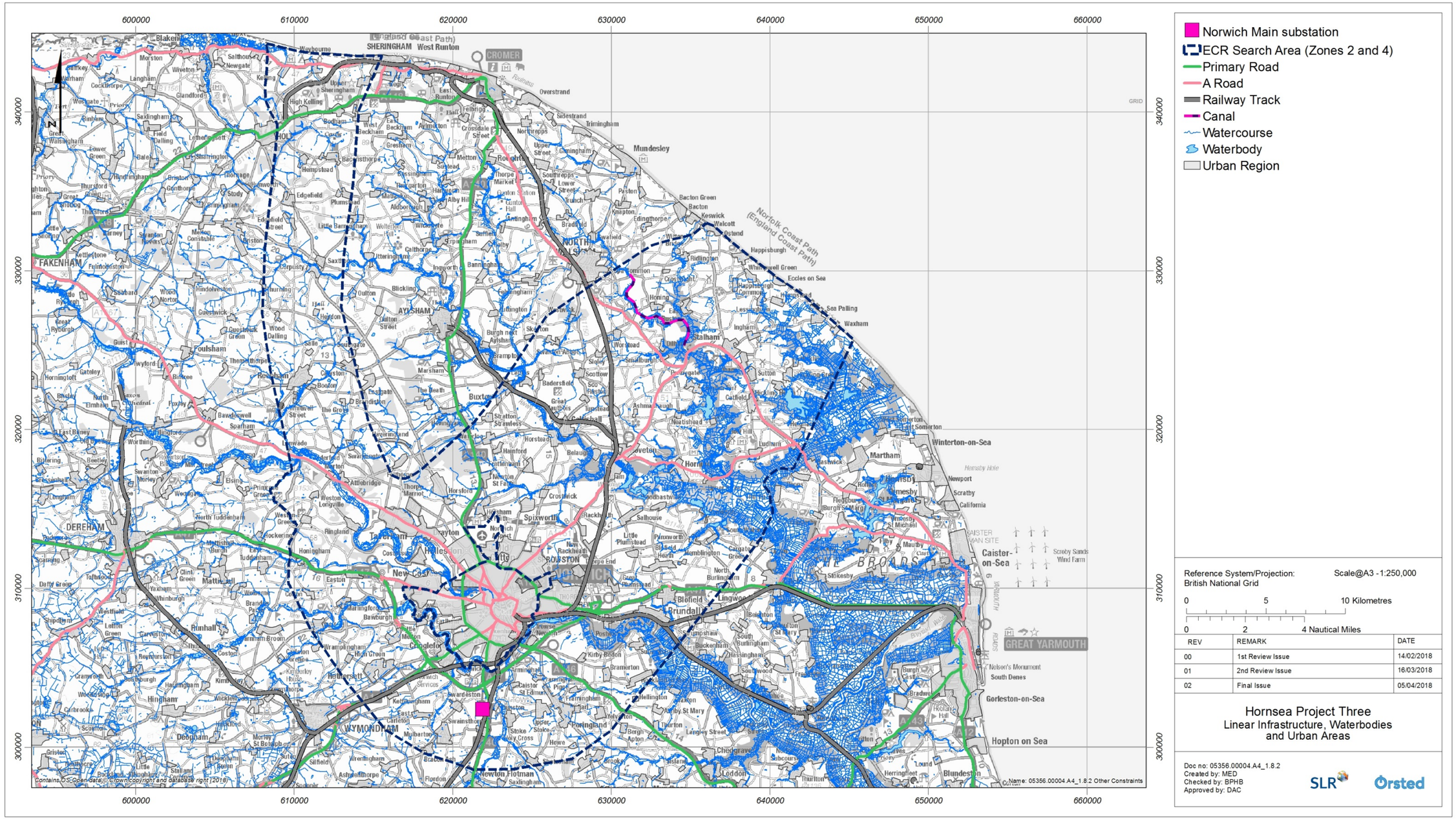

Figure 3.10: Linear Infrastructure, Waterbodies and Urban Areas.

3.5.6 Zone 4 North and West of Norwich General Corridor Analysis

3.5.6.1 A review of Figure 3.7 to Figure 3.10 showed that:

- The Zone 4 corridor north and west of Norwich contained a number of heritage conservation areas, Historic Parks and Gardens and a large number of listed buildings. A particular area of constraint extends around Badesfield and Coltishall. Whilst some construction stage effects may occur routeing was expected to be able to avoid direct effects;
- The ribbon nature of the Norfolk Broads National Park, which follows a number of watercourses, presents particular challenges unless avoided by diversion. Construction risks associated with routes across the National Park were likely to be compounded by challenging ground conditions (extensive wet and marshy areas) increasing construction risks substantially which may be further constrained by seasonal restrictions for ecological reasons. Longer term landscape effects may be capable of mitigation but construction stage effects will be marked;
- Zone 4 routes to the north of Norwich were expected to miss the ecologically designated or ecologically important areas more extensively present towards the south eastern part of the zone. Those ecological sites that were present (SSSI and Ancient woodland) can be readily routed around or in the case of the River Wensum SSSI, which the corridor crosses, were likely to be capable of being acceptably crossed with mitigation;
- Crossings of a number of rail lines and roads were unavoidable but can typically be achieved at 90 degree angles without undue diversion;
- A number of small urban areas (towns and villages) were dispersed along the Zone 4 general corridor though not in such proximity or density to overly constrain routeing; and
- Onshore connection length was expected to be approximately 62 km if it were to avoid the National Park areas.

3.5.7 Zone 4 South of Norwich General Corridor Analysis

3.5.7.1 A review of Figure 3.7 to Figure 3.10 showed that:

- The Zone 4 corridor south of Norwich contained a number of heritage conservation areas, historic Parks and Gardens and a large number of listed buildings. Whilst some construction stage effects may occur routeing was expected to be able to avoid direct effects;
- The ribbon nature of the Norfolk Broads National Park, which follows a number of watercourses, presents particular challenges. Whilst there was some potential to divert the route to avoid this in some sections, the National Park cannot be avoided to the south east of Norwich. Longer term landscape effects may be capable of mitigation but construction stage effects will be marked;
- Unless avoided by diversion, construction risks associated with routes across the National Park were likely to be compounded by challenging ground conditions (extensive wet and marshy areas) increasing construction risks substantially which may be further constrained by seasonal restrictions for ecological reasons;
- Zone 4 routes to the south of Norwich would need careful routeing in order to miss the extensive ecologically designated or ecologically important areas in this south eastern part of the zone. These included National Nature Reserves, SSSI and Ancient woodland;
- Crossings of a number of rail lines and roads were unavoidable but can typically be achieved at 90 degree angles without undue diversion;
- A number of small urban areas (towns and villages) are dispersed along this general corridor. The area to the north of Norwich around Taverham and Horsford was likely to lead to increased route length to minimise impacts on residential amenity; and
- The shortest onshore connection length (but with greatest effects on the National Park) could be approximately 45 km but a connection length of around 56 km was likely to be required to reduce at least some of the effects on the National Park.

3.5.8 Conclusions on the Cable Route Corridor Options between Landfall Zones 2 and 4 and Norwich Main Substation

3.5.8.1 Based on the above it was concluded that connecting from Zone 4 south of Norwich to Norwich Main substation was the poorest performing alternative. Whilst it had potential to be the shortest connection it was likely to be the most challenging in technical and environmental terms principally due to the interaction with the Norfolk Broads National Park and need to cross extensive marshy areas where greater construction stage effects and construction risks would occur. This presented significant risk to a positive outcome and for these reasons this alternative was discounted.

3.5.8.2 Of the other corridor alternatives either from Zone 2 or from Zone 4 landfall north and west of Norwich to the Norwich Main Substation, the corridors on many criteria performed broadly similarly, with none being particularly more, or less, technically challenging than the other.

3.5.8.3 However, cable routing from Zone 4 was potentially more challenging without additional diversion to avoid the Norfolk Broads National Park. Direct routeing would present significant technical challenges for installation (in relation to access and installation techniques) due to the additional marshy conditions in the area of the Norfolk Broads National Park which may also bring additional seasonal restrictions on construction increasing project costs and hence eventual costs to the consumer. Diversion of the route to avoid the National Park and thus avoid these adverse effects meant that the route from Zone 4 to pass to the north and west of Norwich was a much more complex (longer) route which would in itself have significant commercial implications and generally increase adverse effects.

3.5.8.4 On this basis it was concluded that whilst there may be apparent technical ability to connect to the Norwich Main Substation from either landfall Zone 2 or 4, the presence of the Norfolk Broads close to Zone 4, the shorter connection length and therefore generally reduced environmental effects associated with Zone 2, strongly favoured a connection from landfall Zone 2 on both commercial, technical and consenting grounds.

3.6 Offshore Cable Corridor Search Area

3.6.1.1 Volume 4, annex 4.2: Selection and Refinement of the Offshore ECR and HVAC Booster Station, describes strategic consideration of offshore cable corridors to connect to Landfall Zones 2 and 4. In respect of Stage 4 it concludes that both landfall Zones 2 and 4 possessed viable onshore connections. 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 sandscaping associated with the Coastal Management Scheme in the same area, obtaining landfall at Zone 4 was a significantly greater challenge technically. What was understood to be free-spanning of existing infrastructure (where it is no longer supported as a result of seabed movements) also increased concern about the deliverability and commercial acceptability of multiple crossing agreements in this area.. It was acknowledged that various windfarm ECR corridors have the potential to impact upon landfall Zone 2, however it was also considered that they did not create such a pinch point of physical constraints to not be viable. As such, there was clear evidence to support a preference for proceeding with an offshore ECR connecting to landfall Zone 2.

3.7 Preferred Route Option

3.7.1.1 Based on the high level appraisal of the offshore and onshore constraints associated with the two landfall options (Zone 2 and 4) whilst it may be technically feasible to connect from the Hornsea Three array area to the Norwich Main Substation via either landfall option, Zone 2 offered considerably less overall risk from a technical, consenting and commercial perspective for both onshore and offshore elements of the project.

3.7.1.2 Land Zone 2 was therefore taken forward as the preferred option and connection routes from the array to this landfall and on to the Norwich Main Substation.