

East Anglia THREE

Appendix 7.4

Marine Geology, Oceanography and
Physical Processes - Landfall Location
Environmental Baseline

Environmental Statement

Volume 3

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7.4.1	Landfall Location Environmental Baseline

7.4 MARINE GEOLOGY, OCEANOGRAPHY AND PHYSICAL PROCESSES – LANDFALL LOCATION ENVIRONMENTAL BASELINE

7.4.1 Introduction

1. This appendix characterises the baseline physical environment of the offshore cable corridor landfall location for the proposed East Anglia THREE project, covering both the shoreline and nearshore zones. Across these zones, which collectively are called the ‘littoral’ zone, sediment transport processes are active. Note that the baseline physical environment across offshore sections of the offshore cable corridor and the offshore area of sea bed occupied by the East Anglia THREE site are considered separately in *Appendix 7.2*.
2. The offshore cable corridor landfall location for the proposed East Anglia THREE project is shown in *Figure 7.4.1*. This landfall location is identical to that previously assessed in detail for the offshore cable corridor for the East Anglia ONE project and, consequently, this appendix draws heavily from the previous assessments of the baseline physical environment.
3. A comprehensive understanding of the baseline physical environment across the littoral (shoreline and nearshore) zone provides vital context for the subsequent assessment of potential effects arising from the offshore cable corridor landfall for the proposed East Anglia THREE project, which is presented in Chapter 7 Marine Geology Oceanography and Physical Processes of the Environmental Statement (ES). This assessment within the PEIR uses the understanding of the baseline physical environment at the landfall location alongside specific technical detail relating to cable installation approaches and timescales for the proposed East Anglia THREE project to assess the type, magnitude and duration of any potential effects arising from these activities on the baseline physical environment.
4. This appendix was written by Royal HaskoningDHV but incorporates results from earlier assessments of the baseline physical environment at the offshore cable corridor landfall location for the East Anglia ONE project from other contributors, in particular the following documents:
 - Coastal Characteristics at the East Anglia ONE Offshore Cable Landfall (ABPmer 2012);
 - Assessment of Coastal Changes at the East Anglia ONE (ABPmer 2013).
5. Given the extensive work that has previously been undertaken to characterise the baseline physical environment of the offshore cable corridor landfall location for the

East Anglia ONE project, the approach taken in the proposed East Anglia THREE project has been to:

- Review existing relevant data and reports relating to the baseline physical environment of the offshore cable corridor landfall location from the East Anglia ONE project;
 - Consider the need for any additional data acquisition or assessment to fill gaps in knowledge or understanding relating to the baseline physical environment of the offshore cable corridor landfall location for the proposed East Anglia THREE project; and
 - Summarise key aspects of the conceptual understanding of the baseline physical environment of the landfall location.
6. It is important to recognise from the outset that the baseline physical environment is not static but instead will exhibit considerable variability due to cycles or trends of natural change. These can include the short-term effects of storms and surges, the well-observed patterns in the movement of tides during spring and neap cycles and the longer term effects of sea level rise associated with global climate change, for example.

7.4.2 Review of Existing Data and Information

7. The earlier assessments of the baseline physical environment at the offshore cable corridor landfall location for the East Anglia ONE project are reported in the following two documents, both of which have previously been subject to scrutiny by the regulators and their scientific advisors:
- Coastal Characteristics at the East Anglia ONE Offshore Cable Landfall (ABPmer 2012); and
 - Assessment of Coastal Changes at the East Anglia ONE (ABPmer 2013).
8. The first report (ABPmer 2012) was presented as an appendix to the Environmental Statement (ES) for the East Anglia ONE project and provided an overview of the physical processes, coastal defences, coastal movements, Shoreline Management Plan (SMP) policies, conservation and environmental interests and a summary of key aspects of the understanding of the baseline physical environment.
9. The assessment actually covered two possible landfall locations that were being considered at that time, namely Bawdsey and Felixstowe Ferry. Due to this the offshore cable corridor at the landfall location extended in that assessment between

East Lane in the north and Ferry Road, Felixstowe in the south, encompassing the mouth of the River Deben estuary and its associated gravel ebb-tidal delta nearshore bank features called The Knolls. The assessments extended some 1.5km from the shoreline into the nearshore zone.

10. Subsequent to publication of that report, a decision was made to remove the potential Felixstowe Ferry landfall location from further considerations and the EIA for the East Anglia ONE project thereafter focused on the Bawdsey landfall location only. Notwithstanding this, it remains useful to consider the baseline physical environment across the wider area between East Lane and Felixstowe, and extending 1.5km into the nearshore zone, because any impacts directly within the offshore cable corridor at the Bawdsey landfall location (shown in *Figure 7.4.1*) could, potentially, affect the shoreline further south, towards and beyond the mouth of the River Deben estuary. This is due to the physical process and sediment transport interactions that exist along this section of coast between Bawdsey and Felixstowe, which are especially governed by a net (generally) southerly longshore drift of sediment along the shore and periodic changes in the form and location of the gravel banks at The Knolls.
11. The second report (ABPmer 2013) was prepared to address specific comments relating to the baseline physical environment of the offshore cable corridor landfall location that were raised during the Section 56 planning consultation processes to consider the key potential driving factors behind past and ongoing changes to coastal morphology along this stretch of the Suffolk coastline and use this understanding to help infer potential future rates of change over the lifetime of the East Anglia ONE project.
12. Both of the earlier assessment reports for the baseline physical environment at the offshore cable corridor landfall location for the East Anglia ONE project gave due consideration to the findings of several key scientific research reports, peer-reviewed published papers and management documents, namely:
 - Futurecoast (Defra 2002);
 - Shoreline Management Plan (Royal Haskoning, 2010);
 - Southern North Sea Sediment Transport Study – Phase 2 (HR Wallingford et al. 2002);
 - Strategic Environmental Assessment – Area 2: North Sea Geology (Balson et al. 2001);

- A Review of Historical Changes to the Sea Bed of the Greater Thames Estuary (Burningham and French 2008);
- Morphodynamic Behaviour of a Mixed Sand-Gravel Ebb-Tidal Delta: Deben Estuary, Suffolk (Burningham and French 2006);and
- United Kingdom Climate Projections 2009 (or ‘UKCP09’ for short, Lowe et al. 2009).

13. In addition, the earlier assessment reports incorporated analyses of:

- Geophysical survey data of the offshore cable corridor;
- Geological data from a borehole located 50m landward from the cliff edge at Bawdsey;
- Beach and nearshore bathymetric profile surveys between East Lane and Felixstowe that have systematically been collected by the Environment Agency (1991 to 2011);
- Historic Ordnance Survey maps (1880 to 2006);
- Historic aerial photographs (1945 to 2012);
- Lidar datasets (2003, 2008 and 2012);
- Wave data from the ‘Gabbard’ directional wave-rider buoy (2002 to 2013); and
- Wave data from the ‘Bawdsey’ directional wave-rider buoy (2006 to 2007).

7.4.3 Acquisition of Additional Data

14. Having reviewed in detail the previous baseline physical environment assessments at the offshore cable corridor landfall location for the East Anglia ONE project, there are no identified gaps in knowledge or understanding relating to the proposed East Anglia THREE project because both projects share a common offshore cable corridor landfall location and the assessments for the East Anglia ONE project have previously been scrutinised by the regulators and their scientific advisors (Natural England, 2013).
15. Due to this, no further data acquisition has been undertaken specifically for the purpose of characterising the baseline physical environment at the offshore cable corridor landfall location for the proposed East Anglia THREE project.

16. Further information on the specific technical detail relating to cable installation approaches and timescales for the proposed East Anglia THREE project is available, however, and this has been used to assess the type, magnitude and duration of any potential effects arising from these activities on the baseline physical environment within Chapter 7 Marine Geology, Oceanography and Physical Processes of the PEIR.

7.4.4 Summary of Conceptual Understanding of Baseline Physical Environment for the Landfall Location

17. As the baseline physical environment at the offshore cable corridor landfall location for the proposed East Anglia THREE project has previously been described in detail in the reports for the East Anglia ONE project (ABPmer 2012; 2013), the full detail is not unnecessarily repeated here. Instead, following sections provide a summary of the key aspects of the conceptual understanding of the baseline physical environment.
18. The landfall location of the offshore cable corridor for the proposed East Anglia THREE project is shown in *Figure 7.4.1*, but consideration of the baseline physical environment is necessary across a wider frontage of Suffolk coastline, between East Lane and Felixstowe and extending 1.5km into the nearshore zone, because of the physical process and sediment transport interactions that exist along this section of coast.

7.4.1.1 Geomorphology

19. The northern extent of the offshore cable corridor for the proposed East Anglia THREE project is coincident with the promontory at East Lane. This forms a partial barrier to sediment moving south within the littoral zone from Hollesley Bay further north. The defended promontory at East lane also exerts an artificial control on the planform evolution of the shore further south.
20. The Bawdsey foreshore consists of London Clay overlain by marine gravel and sand beaches (ABPmer 2012). The low cliffs are pre-glacial crag deposits, mainly sand and gravel, and represent a small source of sediment to the beach and coast to the south (ABPmer 2012). There is a net southerly sediment transport, but cross-shore transport is also important (Royal Haskoning 2010).
21. There is a large, nearshore, shingle bank system which forms the ebb-tide delta at the mouth of the River Deben estuary. This system is called The Knolls and is a function of the longshore sediment supply from the north which interacts with the flow in an out of the estuary. Periodically, there are changes in the position and form of the banks, driven by storm wave action (Burningham and French 2006).

22. The Knolls are important features in forming a large, temporary, sink for sediment (which at other times can also be a source of sediment to frontages south of the estuary, depending on the prevailing conditions). The banks also act to modify wave action and sediment drift at the mouth of the estuary (HR Wallingford et al. 2002).

7.4.4.2 Water Levels

23. The Suffolk coast is a meso-tidal environment with a relatively small tidal range. At the mouth of the River Deben estuary, the tidal range is 3.2m on spring tides and 1.9m on neap tides.
24. Meteorological effects such as sea surges can elevate or depress water levels notably in this sector of the southern North Sea.
25. Sea level is predicted to increase over the lifetime of the proposed East Anglia THREE project due to a combination of global climate change and changes in the position of the land mass relative to the sea. By 2055 the increase in sea level is projected to be between 0.18 and 0.34m (Lowe et al. 2009). The lower bound of this range represents the 50th percentile value of the 'medium' greenhouse gas emissions scenario, while the upper bound represents the 95th percentile value of the 'high' emissions scenario.

7.4.4.3 Tidal Currents

26. In the nearshore zone, the tidal flows are relatively low and flood towards the southwest and ebb towards the northeast. However, the constrained flow into and out of the estuary gives rise to relatively high flows locally and can create channels cutting through the bank system at the mouth (ABPmer 2012).

7.4.4.4 Waves

27. The dominant offshore directions of wave approach are from the east-northeast and south-southwest. However, the nearshore banks and wider nearshore area significantly influence the inshore wave direction such that net energy tends to approach the coast from the east-southeast (ABPmer 2012).

7.4.4.5 Sediment Transport

28. Along the foreshore in front of the Bawdsey cliffs, the average longshore sediment transport is towards the south, with sediment supplied from the north at Orford Ness. As the beach sediments are mainly shingle, storm activity is important for longshore transport and storm waves primarily approach this section of coast from between the north and northeast sectors. Transport can also occur to the north when waves are from the southeast. However, these waves are associated with

much lower rates of sediment transport and the effects are generally localised (ABPmer 2012).

29. Across the mouth of the Deben, there is generally a low rate of transport to the south, due to the presence of The Knolls which provide a pathway across the mouth (ABPmer 2012).
30. Transport along the north Felixstowe frontage is generally towards the south, but it can be to the north or south depending on the position of The Knolls and the direction of wave attack (ABPmer 2012)

7.4.4.6 Coastal Defences

31. At East Lane there is a recently-constructed rock armour revetment and sheet piling which replaced a sea wall. Along Bawdsey cliffs there are a number of groynes but they are in such a dilapidated condition that they provide little useful coastal defence function. To the south of Bawdsey Manor is sheet piling, tied back to a timber frame with beach fill.
32. A rock armour revetment was recently constructed at Felixstowe Ferry to counter erosion problems being experienced there. At its southern end it links into a large and accreting shingle bank and a concrete recurve wall that extends 500m to the south. This wall is fronted by four rock groynes constructed in 2006 to replace failing timber groynes. A series of groynes backed by sheet piling and a concrete revetment extend across the Felixstowe Ferry Golf Club clubhouse.

7.4.4.7 Coastal Movements

33. Based on analysis of Environment Agency beach profile data between 1991 and 2012 (ABPmer 2013), the beach to the north of East Lane is experiencing erosion, with losses of beach sediment in winter and reduction in the width of the upper beach (between MHWS and MSL) by 40m. The hard defences at East Lane have created an artificial promontory and fixed the position of the shore, but to the south of East Lane the beach is also eroding. The rock armour revetment was placed here following loss of the beach and erosion of the low cliff to protect a Martello Tower.
34. To the south of the Martello Tower, there has been a loss of the sand and gravel sediments of the beach and a consequent lowering of the exposed clay shore platform.
35. At Bawdsey Hill the steep cliff is subject to occasional slumping and the foreshore is eroding.

36. At Bawdsey both the cliffs and the upper beach have historically been relatively stable, although there can be notable seasonal variations in beach form. However, during the autumn of 2012 and winter of 2012/2013 the cliffs experienced undercutting by storm wave action, leading to cliff retreat, and the gravel beach became eroded, leading to exposure and lowering of the London Clay shore platform.
37. The cliffs at Bawdsey Manor are relatively stable, but the foreshore is eroding.
38. Offshore from the mouth of the Deben, the sediment bypassing the mouth forms the banks and bars of The Knolls. These can be variable in both position and form, depending on the prevailing conditions.
39. To the south of the Deben, periodic 'pulses' of sediment can move onshore from The Knolls and then become transported along the shore, generally towards the south.
40. The effects of sea level rise on future erosion rates has been considered in the SMP (Royal Haskoning 2010).
41. Under a theoretical scenario where future evolution is unconstrained by coastal defences, the coastline at Bawdsey cliffs is likely to erode between 15 and 110m over the next one hundred years. At Bawdsey Ferry the range will be 60 to 100m over this time period, whilst at Felixstowe Ferry it will be 75 to 410m and at North Felixstowe it will be 40 to 120m.
42. When existing coastal defences are taken into consideration, it is only at the undefended Bawdsey cliffs where change in shoreline position is likely to be experienced because all other frontages are defended. There will, however, be changes in the elevation of the foreshore and nearshore zone seaward of the defence structures, where present. These are particularly difficult to predict south of the Deben because this location is so critically dependent on the sheltering effect and periodic supply of 'pulses' of sediment from The Knolls.
43. On the basis of theoretical calculations undertaken specifically for the offshore cable corridor landfall location for the East Anglia ONE project (ABPmer 2013), a highly conservative upper bound of retreat of the Bawdsey cliffs over the 25 year operational lifetime of the proposed East Anglia THREE project is 100m (at an average rate of 4m per year). This retreat is associated with sea level rise arising from the 95th percentile value of the 'high' greenhouse gas emissions scenario projected by UKCP09 (Lowe et al. 2009).

44. Similarly, on the basis of analogous monitoring data of London Clay shore platform lowering at Warden Point in Essex and through a comparison of historic bathymetric charts, the intertidal and sub-tidal exposures of London Clay at Bawdsey might be expected to lower by up to 0.75m during the 25 year operational lifetime of the proposed East Anglia THREE project.
45. These assessments of both cliff retreat and shore platform lowering are highly conservative; indeed the cliff retreat projections are notably greater than those made in the SMP, which may be deemed as being more realistic. However, this conservatism has been prompted by episodes of cliff erosion and loss of gravel beach material during the autumn of 2012 and winter of 2012 / 2013 and a desire to ensure that the engineering design adopts a suitably conservative distance from the cliff top at which to site the jointing bays and a suitably conservative depth below the sediment surface for the export cable to ensure they remain buried during the lifetime of the proposed East Anglia THREE project.

7.4.4.8 Shoreline Management Plan Policy

46. The management policies recommended by the SMP along the frontage are shown in *Table 7.4.1*.

Table 7.4.1 – Shoreline management plan policy

Policy Unit		Policy			Comments
		2025	2055	2105	
HOL 16.5	East Lane	HTL	HTL	HTL	Maintain control of drift
HOL 16.6	Bawdsey Hill	NAI	NAI	NAI	Maintain sediment supply to south
DEB 17.1	Bawdsey Cliffs	NAI	NAI	NAI	-
DEB 17.2	Bawdsey Manor	HTL	HTL	HTL	Maintain estuary configuration in general, local decisions on management of individual sections
DEB 17.3	Lower Estuary	HTL	HTL	MR	Allow sustainable management of the estuary
DEB 17.4	Felixstowe Ferry	HTL	HTL	HTL	Manage alignment of the coast. Policy may be reviewed at the end of the first epoch.
DEB 18.1	Golf Course	HTL	HTL	HTL	-
Where: HTL = Hold the Line of Existing Defence NAI: No Active Intervention MR: Managed Realignment					

47. The SMP policies allow the promontory at East Lane to be held, therefore allowing erosion of the shoreline and potentially the cliffs to the south, but at a slower rate than if East Lane was no longer defended.
48. Both the north and south sides of the mouth of the Deben are to be held in position in order to maintain the estuary configuration.

7.4.4.9 Conservation and Environment

49. The intertidal and backshore area of much of the Bawdsey frontage is covered by the Bawdsey Cliffs Site of Special Scientific Interest (SSSI), which is designated for its geological interest. The vegetated shingle beach is also a County Wildlife Site (a non-statutory designation). The whole coastline is part of the Suffolk Coasts and Heaths Area of Outstanding Natural Beauty (AONB).
50. The inner Deben estuary, which although not directly within the offshore cable corridor landfall location for the proposed East Anglia THREE project could be affected by changes in physical processes or sediment transport arising from it, is designated as a Special Protection Area (SPA) and Ramsar Site, as well as a SSSI.

7.5 Summary

51. The coast to the north and south of the offshore cable corridor landfall location for the proposed East Anglia THREE project are generally eroding and this process is likely to increase in the future with sea level rise.
52. The SMP policy over the lifetime of the proposed East Anglia THREE project at East Lane, Bawdsey Manor and to the south of the Deben is to “Hold the Line of existing defences”. This is likely to lead to erosion of the foreshore seaward of the defence structures, with foreshore steepening and a loss of beach material.
53. At Bawdsey cliffs, where most of the offshore cable corridor landfall is located, the SMP policy is “No Active Intervention”. As the shingle beach becomes depleted, it is likely to lead to erosion of the backing cliffs. These are currently relatively stable with only occasional slumping. A highly conservative upper bound of retreat of the Bawdsey cliffs over the 25 year operational lifetime of the proposed East Anglia THREE project is 100m, at an average rate of 4m per year (ABPmer, 2013). A similarly conservative estimate of the changes in the intertidal and sub-tidal exposures of London Clay at Bawdsey is lowering by up to 0.75m during the 25 year operational lifetime of the proposed East Anglia THREE project.
54. The other important changes mainly relate to the natural variation in the shoreline to the south of the Deben due to changes in The Knolls and the variation in shelter

and sediment supply provided by this system of nearshore banks and bars to the Felixstowe shore.

7.6 References

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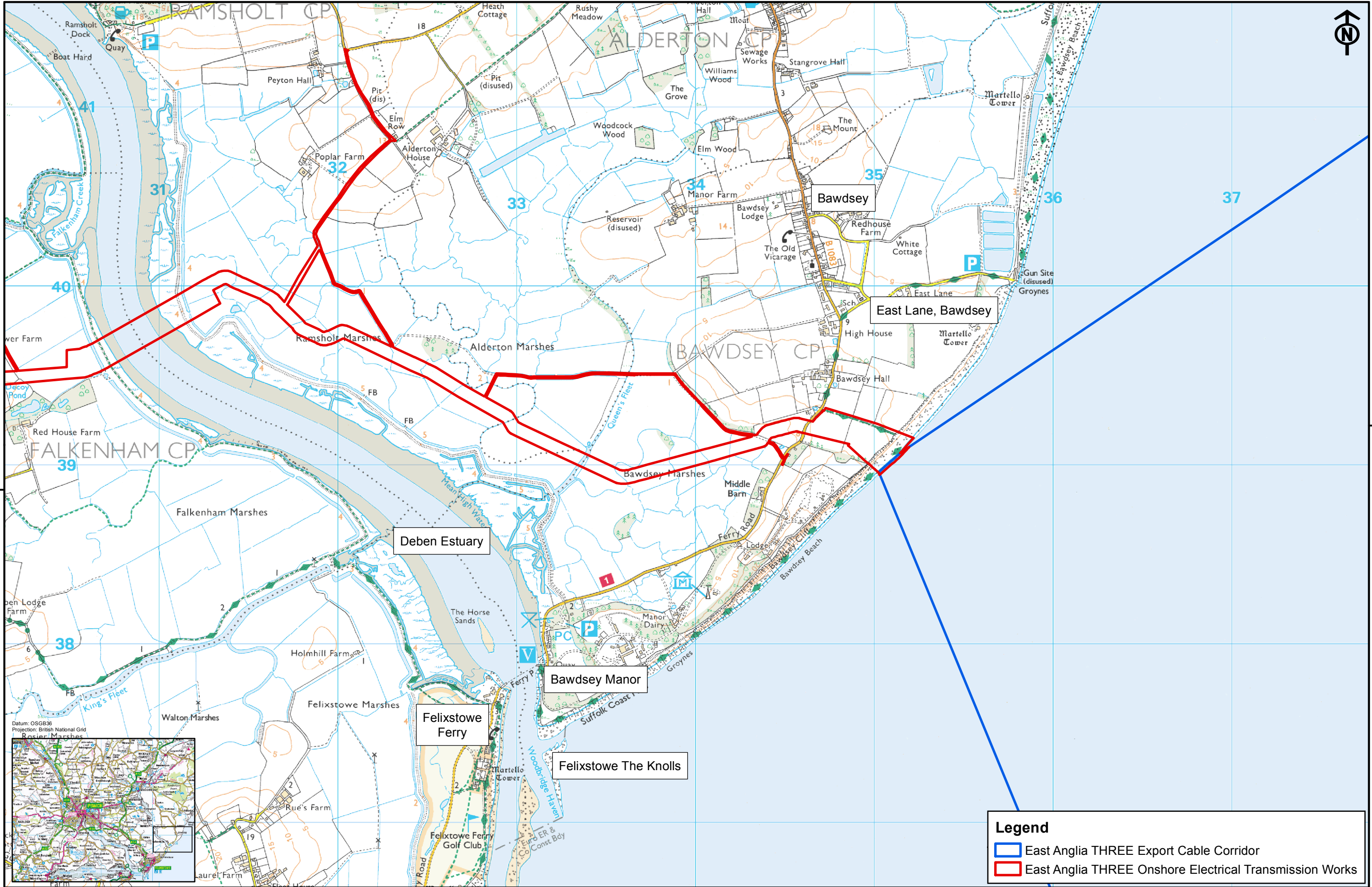
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7.7 Figures

55 Provided below is *Figure 7.4.1*



Legend

- East Anglia THREE Export Cable Corridor
- East Anglia THREE Onshore Electrical Transmission Works

SCOTTISHPOWER RENEWABLES **VATTENFALL**

Rev	Date	By	Comment
2	21/10/15	AB	Second Issue
1	15/07/15	BN	First Issue

Original A3 Plot Scale 1:20,000

0 500 Metres

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Location of Cable Landfall

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Appendix 7.4 Ends Here