East Anglia
Offshore Wind

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SCOTTISHPOWER RENEWABLES

East Anglia THREE

Appendix 7.1
Physical Processes Evidence Plan

Volume 3
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7.1 PHYSICAL PROCESSES EVIDENCE PLAN

7.1.1 Introduction

1. This Appendix contains a number of documents which form the Evidence Plan for Physical Processes, these are:

- Method statement paper used for Expert Topic Group (ETG) meeting 1;
- Minutes from Expert Topic Group meeting 1;
- Emailed confirmation that stakeholders accept minutes from ETG meeting 1;
- Presentation given at ETG meeting 2
- Minutes from ETG meeting
- S42 Consultation with Natural England on the PEIR

2. It should be noted that these documents are as close to their original form as possible and have not been updated as projects have developed. Therefore the timelines and parameters given in section 7.1.2, the method statement, are now out of date. Furthermore, the documents within this appendix refer to the proposed East Anglia FOUR project, which at the time of writing was being progressed in parallel with the proposed East Anglia THREE project; it should be noted that this is no longer the case.

7.1.2 Physical Processes Background Paper for ETG Meeting 1

3. Presented below is the Physical Processes Background paper which was provided to all stakeholders, prior to the first ETG meeting which was held on the 13th of September. Following the meeting a few minor amendments were made to the paper and it was re circulated on the 24th of September. The version provided below was the final version of the paper.

East Anglia Offshore Wind

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East Anglia THREE and East Anglia FOUR Offshore Windfarms

Evidence Plan

Physical Processes Background Paper

Physical Processes Expert Topic Group

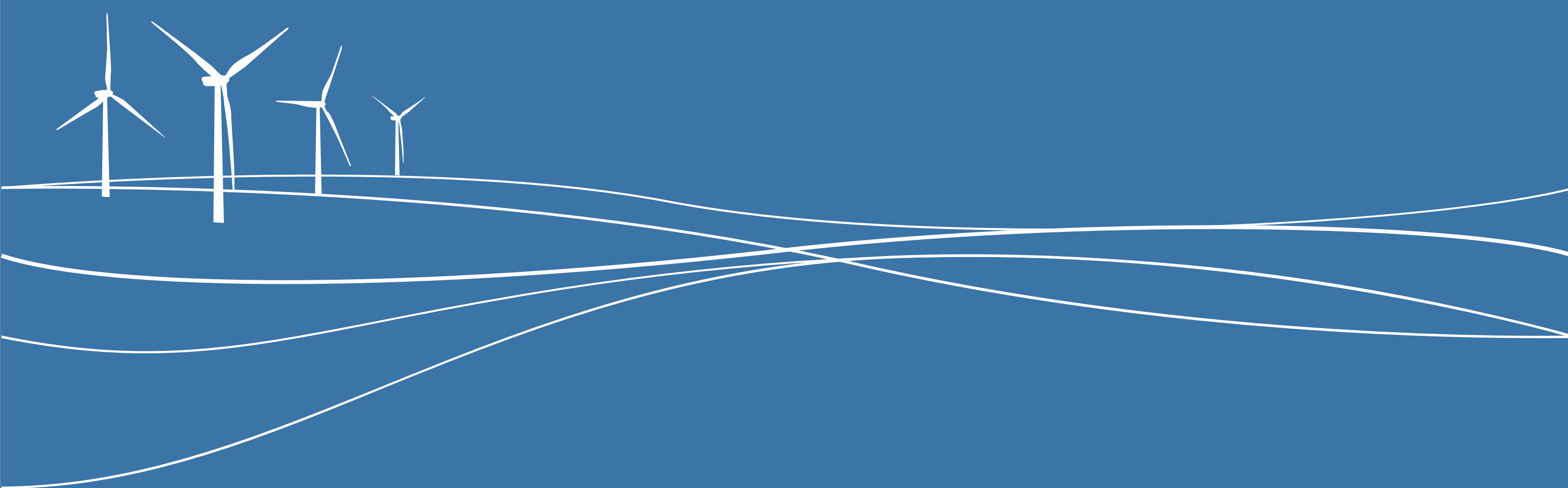
Preliminary meeting: September 2013

Author – Royal HaskoningDHV

East Anglia Offshore Wind Limited

Date – September 2013

Revision History – Revision C



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1 INTRODUCTION

1.1 Background

1. East Anglia Offshore Wind (EAOW) has been awarded development partner status by The Crown Estate for 'Zone 5 – East Anglia' of Round 3 of the offshore wind farm (OWF) development programme.

2. The development at the East Anglia Zone is anticipated to be taken forward in a number of phased projects and to date the Development Consent Order (DCO) for East Anglia ONE has been submitted. The present Method Statement relates to the next phases of development, namely East Anglia THREE and East Anglia FOUR, and their associated OFTO (Offshore Transmission Owner) project.

3. Given the linkages that exist between physical processes and a range of sensitive receptors over various spatial and temporal scales, it is vital that potential changes in those processes due to the development during construction, operation and decommissioning phases are assessed robustly, but in a manner that is proportionate to the risks which are presented. Due to both the staged nature of the development of East Anglia Zone and its relative proximity to other offshore activities, including the North Sea oil and gas fields, shipping routes, the Hornsea Zone and its identified offshore wind farm areas, and marine aggregate dredging sites, such assessments will need to consider the development both alone and cumulatively with other developments. It is also important that due to the proximity to the Suffolk banks, and their role in the sediment circulatory systems in the southern North Sea and their role in providing shelter to the adjacent coast, physical processes are considered both in the offshore areas, and nearer to and along the shoreline.

4. A Scoping Report has been produced for each of East Anglia THREE and FOUR. To date none of the responses relate specifically to physical processes. However the various responses previously received in relation to East Anglia ONE provide a useful indication of the type of physical process issues that will need to be considered. Additionally, industry-wide guidance exists that will need to be followed to demonstrate application of 'best practice' and lessons learned from Rounds 1 and 2 of OWF development. Finally, many project-related or site-related requirements will need to be addressed which are specific to the environmental and physical characteristics of the wind farms within the wider East Anglia Zone and specific to the engineering choices that will be made relating to foundations, layouts and cabling.

1.2 Context for Methodology

5. Assessment of the tidal, wave and sediment regimes, and their influences on morphological change of the seabed and adjacent shorelines, are an essential part of the EIA process associated with offshore wind farms. These assessments were typically undertaken during Round 1 and Round 2 schemes as 'Coastal Process Studies' but as schemes move towards deeper water in Round 3, so 'Physical (Offshore) and Coastal (Nearshore) Process Studies' will be required.

6. The purpose of such studies is to assess and, where necessary and practicable, mitigate the environmental impact of offshore wind farm developments on the physical marine environment. The studies consider both near-field effects (within the development site) and far-field effects (beyond the development site and across the wider regional seabed and coastline). They also consider different phases of the lifecycle of the development, such as construction, operation and decommissioning.

7. The main physical impacts on the marine environment from an offshore wind farm development are associated with the turbine towers and foundations, offshore platforms and foundations, inter-connecting and export cables, and the landfall at the shoreline. Issues or concerns relating to these aspects are likely to involve the potential for:

- Wave interference and interaction
- Changes to the current regime
- Scour effects
- Changes to sediment mobility and turbidity
- Changes to sea bed and shoreline levels
- Changes to the mobility and stability of sea bed features
- Changes to the coastal regime

8. During Round 1 and Round 2 schemes, coastal process impact assessments were undertaken in accordance with best practice guidance from ETSU (2002) and Cefas et al. (2004). Since some of those schemes are now operational, post-project monitoring has since been undertaken and reviewed to evaluate some of the environmental issues. This monitoring has been used to develop new best practice guidance for Round 3 schemes to reflect the lessons learned from Rounds 1 and 2, and the new challenges associated with developments in deeper water

environments. The resulting guidance (COWRIE 2009) highlights five key areas for consideration (Table 1).

Table 1. Key physical and coastal process issues highlighted by COWRIE (2009)

Topic	Issue
1	Suspended sediment dispersion and deposition patterns resulting from foundation and cable installation or decommissioning
2	Changes in coastal morphology due to cable landfall
3	Scour and scour protection
4	Wave energy dissipation and focussing for sites close to shore (typically <5km)
5	Wave and current processes controlling very shallow sandbank morphology especially with less understood foundations types

Note: Topic 4 is not directly relevant to East Anglia THREE & East Anglia FOUR as these sites are in considerably deeper water, further offshore.

2 METHOD STATEMENT

9. This Method Statement is based upon the concept of maximising the value from the considerable work previously undertaken; both for the East Anglia Zone and for East Anglia ONE. It proposes proportionate and pragmatic approaches to investigating the issues which need to be considered for East Anglia THREE and East Anglia FOUR.

2.1 Approach to Offshore Physical Processes

10. The understanding of the offshore physical processes and the effects of the wind farm development on them will follow a staged approach, involving:

- Review of existing project-relevant data;
- Acquisition of additional project-specific data to fill any gaps;
- Formulation of a conceptual understanding of baseline conditions;
- Consultation with regulators regarding proposed assessment approaches (via this Method Statement); and
- Assessment of effects using analytical tools, numerical modelling and empirical methods as defined by this Method Statement.

2.1.1 Review Existing Data

11. The data requirements for a baseline understanding of the offshore physical processes at the East Anglia project areas that will underpin the conceptual understanding and provide input to the numerical modelling and empirical assessments can be classified into two areas: material and process. The material data includes knowledge of the geology of the seabed and sub-seabed, bathymetry, and the lithology and distribution of mobile and non-mobile sediments. The process data includes knowledge of the forcing such as waves, tide-generated currents, their strengths, directions and variability with time, and sediment transport regime.

12. Considerable existing data and information is already in existence relating to the material and processes of the offshore physical environment and much was collated for the East Anglia Zone Environmental Appraisal (ZEA), including from the following sources:

- Marine Renewable Atlas
- Wavenet
- National Tide and Sea Level Forecasting Service

- Environment Agency (extreme sea levels database)
- TotalTide (UKHO tidal diamonds)
- BODC
- POL Class A tide gauges
- Baseline numerical model runs
- UKCP09 climate projections
- BGS 1:250,000 seabed sediment mapping
- BGS bathymetric contours and paper maps
- Admiralty Charts and UKHO raw survey data

13. In addition, considerable literature exists and was reviewed as part of the East Anglia ZEA. This includes some major publications, including:

- Southern North Sea Sediment Transport Study
- Futurecoast
- Shoreline Management Plans
- Thames Regional Environmental Characterisation (REC)
- East Coast Regional Environmental Characterisation (REC)
- East Anglia Marine Aggregate Regional Environmental Assessment (MAREA)
- Industry guidance

14. Numerical modelling was undertaken as part of Metocean Conditions Study (GL Nobel Denton 2011) to inform the East Anglia ZEA. Wind and wave data were obtained from the BMT ARGOSS WaveWatch III model covering a 10 year period (Jan 1999 – Dec 2008), including wave height, period, direction, wind speed and direction in 3hr timesteps. These data were used in a MIKE 21 Spectral Wave (SW) model to produce wave direction extremes at 7 locations, fatigue data (frequency analyses) at 3 locations and spells analyses at 2 locations across the Zone. Of these, two of the locations for wave direction extremes are directly relevant to East Anglia THREE & FOUR. The model was calibrated against measured wave data from the K13, West Gabbard and Southwold buoys available via WaveNet. In addition, a Mike-21

Flexible Mesh (FM) hydrodynamic model was developed. These models provide a useful basis for extracting further metocean parameters from different locations or different time periods across the Zone.

15. Project-specific surveys were also undertaken for the East Anglia ONE project and provide a useful, detailed characterisation of that area of the Zone, including:

- **Metocean survey data** to establish critical relationships between waves, tides and sediment mobility (suspended and bedload sediment transport);
- **Bathymetric survey data** to ascertain the depth and form of the seabed and the presence of bedforms such as sand banks, sand waves and megaripples;
- **Geophysical survey data** to document underlying geology, sediment types and thicknesses, the geometry of bedforms and sediment transport directions; and
- **Benthic survey data** to investigate the chemical and physical composition of surface sediments.

2.1.2 Acquisition of Additional Data

16. To specifically inform the East Anglia THREE and FOUR projects, further **metocean surveys** have been on-going for 1 year since December 2012, with one Acoustic Wave and Current (AWAC) meter and one Directional Wave Rider (DWR) buoy deployed within each project area (in additional to a new DWR in the East Anglia ONE site).

17. A **geophysical survey** of each project area and the East Anglia THREE and FOUR OFTO was completed in October 2012, achieving 100% coverage with in-line spacing of no more than 100m covering sea bed bathymetry, sea bed texture and morphological features, and shallow geology.

18. Grab samples of surface sediments were collected as part of a comprehensive **benthic survey** undertaken in 2010 across the whole East Anglia Zone. In addition further targeted survey has been undertaken in 2013 to cover previously unsurveyed areas, mainly within the East Anglia THREE and FOUR OFTO.

2.1.3 Conceptual Understanding of Baseline Conditions

19. Appendix G of the East Anglia ZEA presents a detailed baseline characterisation for physical processes across the Zone. The baseline understanding was established on the basis of:

- Pre-existing published literature and available data - A large volume of published work and numerous available datasets exist relating to the baseline tidal, wave and sediment regimes and morphological features within the seabed and adjacent coastlines of the southern North Sea. This was collated and comprehensively reviewed as part of the ZEA;

- Metocean, geophysical and benthic surveys collected from the Zone and the Development Area of project EA ONE (Note: the IMO Deep Water route that runs north-south through the Zone was not surveyed originally but survey has been undertaken in 2013); and

- Numerical modelling of baseline tidal flow patterns.

20. Appendix 6.2 of the East Anglia ONE OWF Environmental Statement (Volume 2 – Offshore) then further developed this baseline characterisation of physical processes specific to the East Anglia ONE OWF site and cable corridor. This information is summarised within Chapter 6 of the East Anglia ONE OWF ES.

21. Key information derived from these previous assessments of relevance to East Anglia THREE and FOUR is presented in **Appendix A** of this Method Statement.

2.1.4 Assessment of Effects

2.1.4.1 Previous Assessments

22. Considerable previous work has been undertaken within the East Anglia Zone and specifically for the East Anglia ONE project to assess the potential effects of offshore wind farms on the physical marine environment.

23. Chapter 5 of the East Anglia ZEA presents the Zonal Cumulative Impact Assessment for physical processes, based on a 'Source-Pathway-Receptor' conceptual model. It considered the potential for changes to occur both within the Zone and across the wider physical processes Study Area which covers the seabed of large areas of the Southern North Sea and the adjacent shores of the UK and mainland Europe.

24. The assessment was undertaken using expert judgment, based upon an understanding of tidal excursion, sediment mobility and sediment transport pathways established through detailed baseline studies. It was also informed using an evidence-base established from ES chapters and post-construction modelling associated with operational OWF developments. The assessment process considered issues such as the magnitude of effect, the sensitivity of the receptor, the value of the receptor and the degree of interaction to determine a regional

significance level. The foundation types considered included jackets and gravity base structures (GBS).

25. The principal receptors considered in this assessment included:

- The sensitive coasts within the Study Area;
- Morphological features contained within the offshore EU designated conservation sites;
- Morphological features contained within the coastal EU designated conservation sites; and
- Non-designated banks located in close proximity to the zone, and which may afford protection to the coast by dissipating wave energy.

26. These receptors have the potential to be directly affected by changes to the tidal currents and/or changes to the wave regime, or consequent changes to the sediment regime in terms of transport at the bed, transport at the coast and transport within the water column. It is principally the physical disturbance during foundation or cable installation and the physical presence of the foundations that have the potential to interact with physical processes, causing the changes which may affect the receptors.

27. The findings from this Zonal Cumulative Impact Assessment are presented in **Appendix B** of this Method Statement. It concluded that the only receptor grouping to which possible significant impacts could occur was the sensitive East Anglia coast. There were, however, recommendations for further investigations to be made at the EIA stage of the changes to the tidal current, wave and sediment regimes. These issues were further investigated specifically for East Anglia ONE project and reported in the accompanying ES for that project.

28. Chapter 6 of the East Anglia ONE ES (Volume 2 – Offshore) presents an assessment of the potential impacts on the marine physical processes arising from the East Anglia ONE OWF. This assessment is based on a combination of analysis of site data (including Zone-specific and East Anglia ONE project-specific geophysical, geotechnical, benthic and metocean surveys), consideration of the existing evidence base from the construction and operation phases of other OWF, empirical evaluation using industry standard formulae, and detailed numerical modelling using the Delft3D suite hydrodynamic (FLOW), wave (SWAN) and sediment plume (PART) models. Where modelling has been undertaken, it has been used to quantify the impacts in terms of geographical extent and magnitude of change when compared

against the baseline conditions. Further details regarding the set-up, calibration and application of the numerical modelling tools is provided in the East Anglia ONE OWF Environmental Statement Volume 2, Appendix 6.1.

29. The assessment of potential effects of the East Anglia ONE OWF upon the physical processes was undertaken in three stages:

1. Determination of the baseline physical environment (including climate change effects over the operational lifetime of the project, namely the next 25 years);
2. Determination of the worst case scenario; and
3. Assessment of near-field and far-field effects arising from the WCS during its construction, operation & maintenance, and decommissioning phases using a 'Source-Pathway-Receptor' conceptual model.

30. The assessment process considered the magnitude of an effect in terms of its scale, duration, frequency and reversibility alongside receptor attributes such as the value of the receptor, its tolerance to an effect, its ability to adapt to or avoid an adverse effect, and its recoverability to evaluate a significance level of the effect. Significance was then evaluated ranging from 'not significant', through 'moderate significance' to 'major significance'.

31. The findings from this detailed project-specific ES are presented in detail in **Appendix C** of this Method Statement. A summary overview is provided below.

Construction Phase

- *Tidal and wave regimes*: Impacts upon the hydrodynamic regime, as a consequence of the construction phase, are typically only likely to be associated with the presence of engineering equipment, for example, jack-up barges placed temporarily on site to install the wind turbine structures. As such equipment is only likely to be positioned at one site at a time for a relatively short duration (of the order of days), the consequential effects upon the hydrodynamic regime is deemed to be small in magnitude and localised in both temporal and spatial extent.

- *Sedimentological regime*: it is during the construction phase that the greatest impact upon suspended sediment concentrations and consequential sediment deposition are anticipated. However, impacts are mainly expected to arise only locally around the source of the effect and persist for short time scales (order of hours to days) during the construction period. The effects could be as a consequence of material released during the installation of the structures and/or the cable laying processes.

Operation Phase

32. The East Anglia ONE site covers approximately 300km^2 within which the wind turbines would be installed. The likely number of wind turbines within the area depends on the capacity of those installed; the predicted number ranges from 150 8MW wind turbines to 325 3MW wind turbines. During the operational phase, effects due to the presence of the foundation structures have the potential to be larger in magnitude and in temporal and spatial extents than during other phases.

- *Tidal regime:* Potential effects may include changes to the naturally occurring patterns of tidal water levels, current speeds and directions.
- *Wave regime:* Potential effects may include changes to the naturally occurring wave heights, periods and directions.
- *Sedimentological regime:* Effects upon the sediment regime during the operational phase may occur as a result of the changes to the tidal and wave climate, as above, potentially manifesting as:

  a. The alteration of suspended and/or bed load sediment transport pathways within both the near- and far-fields;

  b. Scour around the wind turbine foundations and/or the cables, with the potential for the eroded material to be transported away from the East Anglia ONE site; and

  c. Changes to the littoral drift processes along adjacent coastlines.

2.1.4.2 Decommissioning Phase

33. On expiry of the lease, all structures would be removed, except cables and pin piles deeper than 1 to 2m, and the seabed returned to a usable state in accordance with the Department of Energy and Climate Change decommissioning guidance (DECC, 2011). Impacts upon tidal, wave and sedimentological regimes as a consequence of this phase would be comparable to those identified for the construction phase.

2.1.4.3 Post-decommissioning Phase

34. Post-decommissioning, the East Anglia ONE site is expected to return to the baseline conditions, allowing for some measure of climate change and within the range if natural variability.

35. Importantly, through all phases of the project's development, the EIA concluded that the potential effects on identified receptors (namely eroding and sensitive coastlines, offshore sandbanks (both designated and non-designated), designated conservation sites, and seabed infrastructure) due to changes in the physical marine environment were not significant (see Appendix C of this Method Statement for further detail of assessment methods and findings).

2.1.4.4 Proposed Assessment Approaches for East Anglia THREE & FOUR

36. The findings from the Zonal Cumulative Impact Assessment and the East Anglia Project ONE ES are important in defining a suitably robust, yet proportionate assessment methodology within this Method Statement for East Anglia THREE and FOUR.

37. There are considerable similarities in the Worst Case Scenario (WCS) considerations in respect of physical processes between East Anglia ONE and East Anglia THREE and FOUR (Table 2).

Table 2. Worst Case Scenarios for Physical Processes for East Anglia Projects

Parameter	EA ONE	EA THREE	EA FOUR
Area	300km^2	370km^2	359km^2
Distance from shore	43.4km at closest point	79km from central point to Lowestoft	91km from central point to Lowestoft
Min water depth	30.5m LAT	35m	25m
Max water depth	53.4m LAT	45m	40m
Indicative capacity	Up to 1200MW	Up to 1200MW	Up to 1200MW
Likely min. no WTG	150 no. (8MW)	120 no. (10MW)	120 no. (10MW)
Likely max. no WTG	325 no. (3MW)	240 no. (5MW)	240 no. (5MW)
Minimum spacing		750m	750m
Cable corridor	73km	140km	160km
Cable landfall	Bawdsey	Bawdsey	Bawdsey
Foundation options considered	GBS (50m diameter), jacket foundations and suction caissons	• 20 – 60m diameter GBS • 15 – 30m diameter suction caisson • 5 – 8.5m diameter monopile 10 – 40m diameter jacket	
WCS surface / shallow depth material displacement for foundations	GBS (seabed preparation, material released at surface of water column)	GBS (seabed preparation, material released at surface of water column)	GBS (seabed preparation, material released at surface of water column)
WCS surface / shallow depth material displacement for cables	Jetting or vertical injector (using jetting) in shallower areas. All cables buried up to 5m in depth	Jetting or vertical injector (using jetting) in shallower areas. All cables buried up to 5m in depth	Jetting or vertical injector (using jetting) in shallower areas. All cables buried up to 5m in depth
WCS sub-surface material displacement	Jacket (drilling)	Jacket (drilling)	Jacket (drilling)
WCS physical blockage	GBS with minimum WTG spacing	GBS with minimum WTG spacing	GBS with minimum WTG spacing
WCS GBS	Max 240 no. modelled but not located in areas where sand waves > 5m in height. Base diameter of 50m. 22,500m^3 sea bed prep. per turbine, max. one GBS installed per	Tbc	Tbc

Parameter	EA ONE	EA THREE	EA FOUR
	day. Spoil deposited within EA ONE site. Scour protection provided, covering an area of 120m x 120m and up to 1m thickness.		
WCS Jackets	Max 325 no. and 50% will be drilled, 50% driven. Each jacket has 4 legs, each up to 2.5m in diameter. Penetration 50m into sea bed. 48 hours to drill each foundation (4 piles). Spoil deposited within EA ONE site (released at surface of water column). Spill volume 245m^3 per pile, 982m^3 per jacket. Assumed 100% disaggregation into component particle sizes. No scour protection.	Tbc	Tbc
WCS Collector and Converter Stations	Up to 3 no. Collectors and up to 2 no. Converters on GBS up to 120m x 120m base. Not included in modelling as additional effects minor in comparison to the array as a whole.	Up to 3 no. Collectors up to 40m(W)x30m(L)x32m(H) on jacket or GBS and up to 2 no. Converters up to 120m(W)x75m(L)x35m (H) on jacket or GBS	Up to 3 no. Collectors and up to 2 no. Converters
WCS Met Masts	1 no. on a suction caisson, jacket or monopile.	Tbc	Tbc
WCS Installation	Jack-up barges with max. 6 no. legs per barge (200m^2 per leg). Max. sea bed depression up to 16m diameter per leg and penetrating up to 3m.	Tbc	Tbc
WCS Cabling	550km inter array cables, 13x10km HVAC	Up to 13 no. HVAC export cables and up	Up to 13 no. HVAC export cables and up

Parameter	EA ONE	EA THREE	EA FOUR
	interconnector cables, 4x100km HVDC export cables. 100% assumed buried.	to 4 no. HVAC interconnector cables OR up to 4 no. HVDC export cables and up to 4 no. HVDC interconnector cables. Combined cable corridor offshore Area of Search with EA FOUR. Significant proportion of offshore cable route shared with EA ONE. 100% assumed buried	to 4 no. HVAC interconnector cables OR up to 4 no. HVDC export cables and up to 4 no. HVDC interconnector cables. Combined cable corridor offshore Area of Search with EA THREE. Significant proportion of offshore cable route shared with EA ONE. 100% assumed buried.
WCS Landfall	HDD exiting below LAT into a pre-trenched channel.	Tbc	Tbc
WCS Construction Programme	Up to 30 months (from first pre-piling to power on final WTG).	Tbc	Tbc
WCS Operational Lifetime	Up to 25 years.	Tbc	Tbc
WCS Decommissioning Programme	Up to 24 months.	Tbc	Tbc

38. Based on these similarities in WCS and the similarities in physical conditions between projects, the assessment approaches proposed for East Anglia THREE and FOUR are provided in Table 3.

Table 3. Physical Processes Assessment Methods for East Anglia THREE and FOUR

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Construction and Decommissioning	Changes in suspended sediment concentrations as a result of GBS sea bed preparation activities and drilling for jacket installation.	**GBS**: 1 foundation installed/day (tbc). Dredging of *surface* sediment (to be characterised by grab samples) and disposal by barge (surface release) in close proximity to each foundation. **Jacket**: 1 jacket installed/48hrs (tbc). Drill release of *sub-surface* sediments (to be characterised by boreholes) per jacket. 100% disaggregation into component particle sizes assumed (not considering cohesion and clastic properties).	Expert-based assessment. This qualitative assessment will draw from the results of previous Zonal Cumulative Impact Assessment (in the ZEA) and detailed modelling previously undertaken for the East Anglia ONE project (in its ES) and be informed by relevant project-specific survey data from the East Anglia THREE and East Anglia FOUR projects.	Modelling for East Anglia ONE shows no significant effect from construction or decommissioning activities for that project. Physical conditions and WCS details are similar between East Anglia ONE and both East Anglia THREE and East Anglia FOUR. Tidal ellipses across the zone show no significant potential for interaction, even within several consecutive tidal cycles, between East Anglia THREE or East Anglia FOUR and sensitive seabed and shoreline receptors. Sediment characteristics indicate only a very small proportion of fine sediment content and therefore sediment plumes are expected to be limited and sediment will fall to the seabed in relatively close proximity to its point of release into the water column. Consultation with regulators (Cefas and Natural England) on 10th September 2013 has identified no significant concerns from these construction/decommissioning activities for East Anglia THREE and East Anglia FOUR in relation to potential effects on fisheries or benthic ecology.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Construction and Decommissioning	Changes in bed levels and sediment type at the sea bed as a result of GBS sea bed preparation activities and drilling for jacket installation.	As above.	Expert-based assessment.	As above.
Construction and Decommissioning	Changes in suspended sediment concentrations, bed levels and sediment type as a result of inter-array cable installation activities.	Up to 550km of inter-array cable. Dredging in areas of large ripples and sand waves.	Expert-based assessment.	As above.
Construction and Decommissioning	Changes in suspended sediment concentrations, bed levels and sediment type as a result of offshore cable installation activities.	Jetting to bury cable to a depth of 5m along the entire offshore cable route.	Expert-based assessment.	As above. Also, the inshore section of the offshore cable corridor is common with that previously assessed using numerical modelling techniques for East Anglia ONE.
Construction and Decommissioning	Interaction between bed preparation and foundation installation within the East Anglia THREE / FOUR wind farm and sediment plumes created by installation of the East Anglia THREE / FOUR offshore cable.	Construction programmes overlap such that plumes coalesce.	Expert-based assessment.	As above.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Construction and Decommissioning	Indentations on sea bed left by vessels (vessel jack-up and anchoring operations).	Up to 6 legs of a jack-up barge. Each leg will have a maximum diameter of 16m and form footprint between 50 – 200m^2. Penetration will be between 0.5 – 3m into the bed. Anchor arrays (of 4 – 6 no. anchors) will typically be smaller than jack-up legs.	Expert-based assessment.	Effects will be minor and localised.
Construction and Decommissioning	Disruption to coastal morphology at cable landfall.	Horizontal Directional Drilling (HDD) at landfall at Bawdsey.	Expert-based assessment. This will involve a re-appraisal of the previous assessment work within the context of the respective construction programmes for East Anglia THREE and East Anglia FOUR.	The ES for East Anglia ONE provided a detailed assessment of landfall effects and the offshore cable for East Anglia THREE / FOUR will share a common landfall location to East Anglia ONE. See also Section 2.2 for a more detailed discussion.
Operational	Changes to the tidal regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	Expert-based assessment. This will involve delineation of an indicative zone beyond which the effects are likely to be diminished.	Evidence from previous wind farm assessments (including post-construction monitoring), East Anglia ZEA and East Anglia ONE ES identifies changes will be local to each foundation.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Operational	Changes to the wave regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	Expert-based assessment. This will involve delineation of an indicative zone beyond which the effects are likely to be diminished. It will also consider the relative effects of different foundation types in different water depths experienced across each of East Anglia THREE and East Anglia FOUR.	Evidence from previous wind farm assessments (including post-construction monitoring), East Anglia ZEA and East Anglia ONE ES identifies changes will be local to each foundation.
Operational	Changes to the sediment transport regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	Expert-based assessment.	Evidence from previous wind farm assessments (including post-construction monitoring), East Anglia ZEA and East Anglia ONE ES identifies changes will be local to each foundation.
Operational	Scour effects due to the presence of the foundation structures, resulting in erosion, re-suspension and settling of sediments.	Jackets (no scour protection planned) and GBS (scour protection provided) both considered.	Empirical scour assessments and expert-based assessment.	Consistent approach with industry best practice.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Operational	Scour effects due to the exposure of inter-array and offshore cables and/or cable protection measures to unburied lengths of cable. This issue may be particularly concentrated at cable crossings.	Inter-array and offshore cables buried along 90% of their cumulative length. 10% of cumulative length may require some form or armouring (e.g. single armour or double armour) or protection on the seabed (rock berms, filled geotextile bags, concrete mattresses).	Either: (1) Expert-based assessment – if the areas where cable burial cannot be achieved are distant from active seabed or shoreline features and do not interrupt active seabed or shoreline sediment transport processes; or otherwise (2) Empirical tools or modelling to determine the relative effect on sediment transport processes.	Method to be confirmed and agreed with Cefas and Natural England following more detailed engineering considerations of geophysical survey data and identification of where cable burial may not be achievable. This may require a 'stand-alone' note to be agreed with Cefas and Natural England to describe the WCS details (including cable crossings) and proposed assessment methodology.
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia THREE/FOUR construction (including offshore cable installation) and construction of other wind farms.	Consideration of any other wind farms located within one spring tidal excursion ellipse from the East Anglia THREE/FOUR OWF	Expert-based assessment. This qualitative assessment will draw from the results of previous Zonal Cumulative Impact Assessment (in the ZEA) and detailed modelling previously undertaken for the East Anglia ONE project (in its ES) and the expert-based assessment of effects arising from each of East Anglia THREE and East Anglia FOUR individually. It will also be informed by relevant project-specific survey data from the East Anglia THREE and East Anglia FOUR projects.	East Anglia THREE and FOUR share a common boundary so in places are located within one tidal excursion ellipse. Consideration will be given in the assessment for the potential for interaction, dependent on the synchronicity (or otherwise) or construction programmes for each project. Consultation with regulators (Cefas and Natural England) on 10th September 2013 has identified no significant concerns in relation to potential cumulative effects on fisheries or benthic ecology.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia THREE/FOUR construction (including offshore cable installation) and installation of other offshore wind farm offshore cables.	Consideration of any other wind farms' offshore cables being installed at the same time and located within one spring tidal excursion ellipse from the East Anglia THREE/FOUR OWF	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. Offshore cable for East Anglia THREE/FOUR will be common along much of its length and also common for much of its length with East Anglia ONE.
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia THREE/FOUR construction and marine aggregate dredging.	Consideration of any marine aggregate dredging located within one spring tidal excursion ellipse from the East Anglia THREE/FOUR OWF	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. There are no marine aggregate dredging sites within one tidal excursion ellipse from East Anglia THREE/FOUR.
Cumulative Effects	Changes to the current regime as a result of the combined activities of East Anglia THREE/FOUR operation and bed level changes from marine aggregate dredging.	Changes in current speed arising from an array of WTGs founded on GBS	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. Changes in current speed are expected to be very local to each foundation.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Cumulative Effects	Changes to the wave regime as a result of the combined activities of East Anglia THREE/FOUR operation and bed level changes from marine aggregate dredging.	Changes in wave regime arising from an array of WTGs founded on GBS	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. Significant changes in wave regime are not expected to extend to aggregate dredging areas.
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia THREE/FOUR offshore cable installation and marine aggregate dredging.	Consideration of any marine aggregate dredging located within one spring tidal excursion ellipse from the East Anglia THREE/FOUR OWF and offshore cable	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. There are no marine aggregate dredging sites within one tidal excursion ellipse from East Anglia THREE/FOUR.
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia THREE/FOUR construction (including offshore cable installation) and disposal of dredged material.	Consideration of any dredge disposal activities located within one spring tidal excursion ellipse from the East Anglia THREE/FOUR OWF and offshore cable	No further assessment.	Consistent with approach agreed with regulators for East Anglia ONE. There are no dredging disposal sites within one tidal excursion ellipse from East Anglia THREE/FOUR.

Phase	Potential Impact	WCS Details	Proposed Assessment Method	Justification
Cumulative Effects	Interaction between East Anglia THREE/FOUR wind farm and other wind farms in the region, causing a change to the hydrodynamic regime and associated changes in sediment transport.	Array of WTGs founded on GBS	Expert-based assessment. The results from expert-based assessments for each wind farm project individually will be interpreted within the context of potential cumulative effect.	Evidence from previous wind farm assessments (including post-construction monitoring), East Anglia ZEA and East Anglia ONE ES identifies changes in the hydrodynamic regime will be local to each foundation.

2.2 Approach to Coastal Processes

39. There has been a long history of concern along the Suffolk coast relating to offshore activities, especially marine aggregate extraction, and their *perceived* effect on coastal processes at the shoreline. This particularly relates to dredging on/near sandbanks, changes in wave climates which may alter nearshore sandbank stability and direct effects from cable landfall at the shore. This concern has led to a number of detailed studies to address these issues. Particularly, the Southern North Sea Sediment Transport Study and the Shoreline Management Plan 2 provide considerable detail on the effects of marine aggregate dredging on nearshore banks, and the East Anglia ZAP and East Anglia ONE ES consider cable landfall effects on the shore at Bawdsey.

40. Given that East Anglia THREE and FOUR are envisaged to have no major effects on wave climate or tidal flows, they will not cause significant changes to the nearshore sandbank systems. This has previously been demonstrated using detailed modelling approaches for East Anglia ONE and East Anglia THREE and FOUR are located further offshore, generally in deeper water and will have no significant effect in this context.

41. The East Anglia ONE ES presented a detailed assessment of the baseline characteristics of the coastal morphology and processes along Bawdsey and adjacent frontages (Appendix 6.3) and an assessment of the potential effects arising from the offshore cable landfall from that project (Chapter 6). The offshore cables from East Anglia THREE and FOUR are intended to make landfall within the same corridor as has previously been assessed for East Anglia ONE, and shown to have no significant effect. Therefore our approach to the cable landfall assessments for East Anglia THREE and FOUR is to review the existing data and apply expertise based interpretation in the assessments within the context of the construction programmes for each of East Anglia THREE and East Anglia FOUR.

3 TIMELINES

42. This section provides indicative timelines from inception to completion of the Physical Processes Assessments for East Anglia THREE and East Anglia FOUR.

Table 4 Key dates

Task	Date
Benthic Grab Samples (ZEA)	Available in 2010
Benthic Grab Samples (Additional Samples)	August 2013
Metocean Survey	East Anglia THREE and East Anglia FOUR commenced December 2012 (1 year) East Anglia THREE and East Anglia FOUR spring and neap ADCP East Anglia ONE DWR (3 years)
Preparation of Method Statement	July/August 2013
Geophysical Data EA THREE	August 2013
1st Evidence Plan Meeting Discussion of Method Statement	13th September 2013 • Welcome and Introductions • Brief Background the East Anglia Zone Projects • Physical Processes Background • Previous Assessments of Effects • Proposed Assessment Methods for East Anglia THREE & FOUR • Timeline • Statement of Common Ground • Summary of Key Actions • AoB • Future Meetings
Confirmation of Method Statement	September 2013
Baseline Assessments EA THREE & EA FOUR	October/November 2013
Project Design EA THREE & EA FOUR	September/October 2013
Geophysical Data – OFTO	November 2013
Assessment of Effects EA THREE	November/December 2013
PEI (1st Draft) EA THREE	January 2014
Geophysical Data EA FOUR	January 2014
Assessment of Effects EA FOUR	February 2014
PEI (1st Draft) EA FOUR	January / February 2014

Task	Date
2nd Evidence Plan Meeting	February/March 2014 • Discussion of (Draft) Assessment Findings
PEI (Submission) EA THREE & EA FOUR	May 2014
Post PEI submission workshop	*Summer 2014* • *Discussion of outstanding issues (if required)* • *Discussion of DCO wording and licence conditions*
Submission of EA THREE ES	November 2014
Submission of EA FOUR ES	Spring 2015

4 REFERENCES

Cefas, 2004. *Offshore wind farms: guidance note for Environmental Impact Assessment in respect of FEPA and Coast Protection Act requirements*.

COWRIE, 2009. *Understanding the environmental impacts of offshore wind farms*. ISBN- 978-0-9565843-8-0.

ETSU, 2002. *Potential effects of offshore wind farms on coastal processes*.

GL Nobel Denton, 2011. *Metocean Conditions Study*. Report No. L24718.

APPENDIX A – BASELINE ASSESSMENT

1. Water Levels

1. The Zone is located within an area of sea bed that is subject to a micro-tidal regime, with the average spring tidal range varying between approximately 0.1m and 2.0m. This low tidal range is due to proximity to an amphidromic point that is positioned just outside the central, eastern boundary of the Zone. At the amphidromic point, the tidal range is near zero. Tidal range then increases with radial distance from this point. The crest of the tidal wave at high water circulates around this point once during each tidal period. As a result of this feature, the tidal range within the Zone is largest in the north and the south of the Zone and least towards the central eastern area of the Zone.

2. With progression along the export cable corridor, the tidal range increases. At the shore it reaches a value of 3.6m on mean spring tides at Harwich (located approximately 7km to the south-west of the cable landfall). The suite of astronomical tidal levels reported by the UK Hydrographic Office's Admiralty Tide Tables is presented in Table A1.

Table A1 – Astronomical tidal levels at Harwich

Water Level	Abbreviation	Level (mCD)
Highest Astronomical Tide	HAT	4.4
Mean High Water of Spring Tides	MHWS	4.0
Mean High Water of Neap Tides	MHWN	3.4
Mean Sea Level	MSL	2.1
Mean Low Water of Neap Tides	MLWN	1.1
Mean Low Water of Spring Tides	MLWS	0.4
Lowest Astronomical Tide	LAT	-0.1
Mean Spring Tidal Range	MWHS - MLWS	3.6
Mean Neap Tidal Range	MWHN - MLWN	2.3

3. Due to global climate change and local land level changes, mean sea level is expected to be between 19 and 27cm higher by 2050 than 1990 values.

4. The North Sea is particularly susceptible to storm surges and water levels can become elevated between 1.5 and 1.7m above astronomical tidal levels under a 1 in 1 year return period surge event, and between 2.3 and 2.5m under a 1 in 100 year return period surge event. Climate change is projected to have an insignificant effect on storm surges over the lifetime of the development.

2. Currents

5. The tidal flow patterns as modelled using the Delft 3D FLOW software are generally to the south south-west during the peak of the flooding tide and to the north north east during the peak of the ebbing tide. Tidal current speeds show spatial variation across the Zone, with stronger currents in the south and west during spring tides.

6. The fastest recorded flows within the Zone are typically associated with the ebb tide, with speeds reaching in excess of 1.2m/s. The weakest currents are observed in the northeast of the Zone in deeper water where maximum speeds, even on the ebb tide, do not exceed 0.9m/s. Despite the low tidal range, the tidal currents within the Zone remain strong due to the rapid, anti-clockwise circulation of the tide around the amphidrome.

7. Further afield, tidal currents increase in the shallow waters nearer to shore, especially just offshore from Norfolk to the west of the Zone.

8. Storm surges elevate currents by up to 0.4m/s during a 1 in 50 year return period event, typically orientated in a south south-westerly direction.

3. Temperature, salinity and frontal systems

9. The waters of the southern North Sea are generally well-mixed throughout the year, whereas the central North Sea, to the north of the Zone and across the Norfolk banks, tends to be vertically-stratified during the summer. There is an intermitted current that follows a northeastwards pathway from the Outer Thames area towards the island of Texel in the Netherlands; this is called the English River.

4. Wind and wave regime

10. The wave regime across the Zone, which is highly episodic and exhibits strong seasonal variation, is comprised of swell waves generated offshore and locally-generated wind-waves. The dominant wind direction is from the south-west, with prevailing waves from the south-southwest in the north of the Zone and from the

north-northeast in the south of the Zone. A general north-south reduction in maximum observed wave heights occurs across the Zone. On the northern boundary, a 1 in 50 year return period event has a significant wave height in excess of 8m whereas on the southern boundary a corresponding event has a significant wave height below 6.5m.

11. Across the majority of the Zone, water depths are likely to be sufficient to limit the effect of wave action on seabed sediments, apart from during exceptionally stormy seas or over shallower areas.

12. Closer to shore, however, water depths reduce and wave effects become more important. At shallow water locations off the East Anglian coast, waves are dominated by short period wind-waves and generally reveal a predominant wave direction from the east. Along the shore itself the wave energy varies significantly and in places is heavily influenced by the sheltering effect of nearshore banks.

13. Climate projections indicate that wave heights in the southern North Sea will only increase by between 0 and 0.05m by 2100.

5. Sediment regime

14. The geology within the Zone generally consists of geologically recent superficial sand deposits overlying a series of Quaternary sands and clays. The depth of surficial sediment across the Zone varies from <1m across most of the site to greater than 20m in the sandwave fields and on the sandbanks, especially to the north of the Zone.

15. The grab samples collected across the Zone correspond well with existing BGS seabed sediment data and reveal that across 90% of the Zone the Holocene sediments consist of either sand, slightly gravelly sand or gravelly sand. Remaining areas are primarily characterised by sandy gravel, although there are localised pockets of muddy sand and (slightly) gravelly muddy sand present. However, over 85% of the grabs contained less than 5% mud-sized material. The median grain size from over 75% of the samples was within the medium sand range (250 – 500 microns). Between 80-100% of the gravel sized fraction comprises biogenic material (e.g. shells and shell fragments). Some boulders are scattered across the seabed within the Zone.

16. There are limited spatial variations in sediment type across the Zone, with the western portion dominated by gravelly sand, the northeastern portion dominated by slightly gravelly sand and areas of muddy sandy gravel in the northwestern portions.

6. Process controls on sediment mobility

17. Across the Zone sediment transport pathways have been extensively investigated in previous studies and through analysis of the orientation of bedforms. Sandwaves present within the Zone exhibit a consistent asymmetry that implies a net direction of transport to the north. Tidal currents are the main driving force of sediment transport and, due to the tidal asymmetry, move sediments in a northerly direction across the Zone.

18. Suspended sediment concentrations across the Zone are typically in the range 1 to 35mg/l and the highest values are typically found along the western margin and during winter months. The English River current can transport suspended sediments largely derived from eroding areas of cliffline along the English east coast offshore in a northeasterly direction across the Zone towards the Netherlands, causing a sediment plume which can elevate levels of suspended sediment. During the LOIS project, measurements within the Zone recorded a maximum turbidity value of 83mg/l, but a mean value of only 15mg/l during and 18 month deployment.

19. Suspended sediment concentrations nearer the coast can be greater and values up to 170mg/l have been recorded in the vicinity of the coast at Great Yarmouth.

20. During storm surges, bedload transport can be dominated by southerly drift across the Zone and suspended sediment concentrations can become enhanced. Locally, more complex transport patterns exist around the Norfolk banks.

21. Along the East Anglian coastline, longshore drift is generally to the south, although localised departures from this trend are apparent at the mouths of estuaries. Seaward of approximately the 20m isobath, even large waves have a very limited influence on the seabed processes.

7. Morphological Regime

22. Within the Zone water depths are generally over 30m LAT, although they vary from a minimum of 6m LAT on top of Smiths Knoll sandbank in the northwest of the Zone to as much as 76m LAT in the south.

23. The most significant bathymetric feature is the deep north-south trending Lobourg Channel located close to the western margin of the Zone. This is an early Pleistocene palaeovalley which was active during periods of lower sea level.

24. Active bedforms are controlled principally by tidal flows and are found across the Zone in the form of sandbanks, sandwaves and sand ribbons. The Great Yarmouth Inner Banks, found to the west of the Zone, are valuable elements of the natural coastal protection, dissipating the energy of waves. These banks are however known to be mobile. A series of sandbanks to the northwest of the Zone are collectively terms the North Norfolk Banks and represent the most extensive example of the offshore linear ridge sandbank type in UK waters. The sandwaves are present across much of the Zone, often with mega ripples of heights between 0.2 and 2m. The sand ribbons are mainly located along the western margin of the Zone.

25. The Norfolk and Suffolk coasts are largely comprised of low-lying, soft rock and unlithified sedimentary geology, making them highly susceptible to erosion under wave action at the shore.

APPENDIX B – SUMMARY OF ZONAL CUMULATIVE IMPACT ASSESSMENT

1. Changes to the tidal current regime

1. On the basis of modelling analyses for previous OWF developments, post-construction monitoring and published guidance documents, changes to flow speeds are expected to the greatest in the immediate vicinity of the foundation structures and reduce with increased distance away. Outside of the array, it was considered that changes in flow speed would be confined to within one peak spring tidal excursion of the array boundary.

2. The assessment concluded that the potential cumulative impacts to identified receptor groups arising from changes to the tidal current regime were not significant, but it recommended that the effect should be considered further at the EIA stage in respect of the Norfolk Natura 2000 site, the Suffolk Natura 2000 site and the nearby non-designated banks.

2. Changes to the wave regime

3. A number of simple empirical relationships were used to determine the interactions between waves and foundation structures and then expert judgement was used alongside an analysis of the predominant wind and wave directions to determine the effect of wave blocking caused by different foundation types on the identified receptor groups. It was considered that the largest changes to individual wave heights would occur within the Zone, with wave shadowing in a down-wave direction of each foundation.

4. The assessment concluded that the potential cumulative impacts to identified receptor groups arising from changes to the wave regime were not significant, but it recommended that the effect should be considered further at the EIA stage in respect of the Norfolk Natura 2000 site, the Suffolk Natura 2000 site, the East Anglia coastline and the nearby non-designated banks.

3. Consequent changes to the sediment transport regime

5. Following analyses of residual tidal current vectors, residual bedload transport vectors and other regional bedload transport indicators, it was identified that across almost the entire Zone, sediment transport is in a northerly direction across the seabed. Along the coastline of East Anglia, sediment transport is generally to the south, although local reversals to this broad pattern may occur at the mouths of

estuaries and inlets. The suspended sediment transport regime was identified through a review of existing literature to be strongly influenced by the 'English River', an advective current along the interface between the seasonally stratified water to the north and the well-mixed water to the south that flows intermittently northeastwards from the Outer Thames area towards the island of Texel in the Netherlands.

6. The assessment concluded that the potential cumulative impacts to identified receptor groups arising from changes to the sediment transport regime were not significant for all but one receptor group, but it recommended that the effect should be considered further at the EIA stage in respect of the Norfolk Natura 2000 site. The potential cumulative impacts to the sediment transport regime at the East Anglia coast were considered to be of moderate significance since at its closest point this coastline is only 15km from the boundary of the Zone.

4. Summary

7. Within the Zonal Cumulative Impact Assessment, the only receptor grouping to which possible significant impacts could occur was identified to be the sensitive East Anglia coast. There were, however, recommendations for further investigations to be made at the EIA stage of the changes to the tidal current, wave and sediment regimes.

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APPENDIX C – SUMMARY OF EAST ANGLIA ONE ENVIRONMENTAL STATEMENT

Phase	Potential Impact	WCS Details	Assessment Method	Assessment of Effect
Construction and Decommissioning	Changes in suspended sediment concentrations as a result of GBS sea bed preparation activities and drilling for jacket installation.	**GBS**: 1 foundation installed/day. Dredging (in areas of sand waves) of up to 22,500m^3 of *surface* sediment (characterised by grab samples, with 75% being medium sand and only 2% being mud) per foundation and disposal by barge (surface release) in close proximity to each foundation. **Jacket**: 1 jacket installed/48hrs. 50% of the 325 WTG jackets would be drilled, releasing 982m^3 of *sub-surface* sediments (characterised by boreholes, clays, silts and sands) per jacket. 100% disaggregation into component particle sizes assumed (not considering cohesion and clastic properties).	• Numerical modelling using Delft3D-PART (15 plume releases over a 15 day spring-neap cycle run) • Standard empirical equations (mobilisation and settling of sediment particles) • Existing evidence base from marine aggregate dredging industry • Conceptual understanding of potential impact • Interpretation against baseline SSC values (summer and winter) and storm effects	Short term and localised increases in SSC may affect other receptors (e.g. marine water quality, fish, benthic ecology and marine mammals). Given the sediment types and tidal currents considered, the majority of sediment from GBS installation will rapidly (seconds to minutes) descend to the sea bed as a high concentration dynamic phase plume. It will form a mound on the bed, spreading radially under gravity. The remainder of the sediment will form a passive phase plume and become dispersed by tidal action before subsequently falling to the bed. Sands within this plume will settle within around 20 minutes of release, extending over an area of up to 1km. Finer sediments may persist for longer (hours to days) and travel over a wider area, with net movement to the north. For jackets, due to the finer nature of the sub-surface sediments, material may be transported over tens of kilometres from the release points. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Changes in bed levels and sediment type at the sea bed as a result of GBS sea bed preparation activities and drilling for jacket installation.	As above.	• As above.	For GBS, up to 2m thickness of deposition due to dynamic phase plume over a likely worst case area of 100m x 100m (10,000m^2) near to each foundation. Less than 0.2mm thickness of deposition of finer material over a wider area during the passive phase plume. For jackets, up to a few centimetres of deposition of sand within a few hundred metres of release, with less than 0.025mm thickness of deposition of finer material over a considerably wider area during the passive phase plume. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Potential release of contaminants from the Warren Springs Environmental Disposal Site.	Potentially affected by GBS sea bed preparation activities, as described above.	• As above.	Fate of contaminants dependent on release and deposition of bed sediments, as assessed above. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Changes in suspended sediment concentrations, bed levels and sediment type as a result of inter-array cable installation activities.	Up to 550km of inter-array cable. Dredging in areas of large ripples and sand waves.	• Conceptual understanding of potential impact	Subordinate scale of potential impact compared against foundation installation, assessed above. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Changes in suspended sediment concentrations, bed levels and sediment type as a result of offshore cable installation activities.	Jetting to bury cable to a depth of 5m along the entire offshore cable route.	• Numerical modelling using Delft3D-PART • Existing evidence base from industry best practice guidance (BERR, 2008) and other wind farms (e.g. Nysted, Kentish Flats, Cromer) • Conceptual understanding of potential impact • Interpretation against baseline SSC values (summer and winter) and storm effects	Short term and localised increases in SSC due to installation, but baseline SSC values in shallower waters nearer to shore are greater than those further offshore across the wind farm site. Localised (<1km of release) concentrations up to 400mg/l in very shallow water, typically <100mg/l in deeper water (>20m water depth). Dispersion of fine-grained material within 180 hours of release. Bed level changes of up to 2mm observed within a few hundred metres and up to 0.2mm observed 20km from cable. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Interaction between bed preparation and foundation installation within the East Anglia ONE wind farm and sediment plumes created by installation of the East Anglia ONE offshore cable.	Construction programmes overlap such that plumes coalesce.	• Conceptual understanding of potential impact (based on tidal excursion ellipses)	There is only limited opportunity for plume combination due to the arrangement of the layout and cable route with respect to the tidal excursion ellipses. The combined plume may cover a slightly larger geographical area and, for a very short period of time, locally exhibit higher concentrations than assessed for foundation and offshore cable plumes individually. However, this higher concentration plume would not be expected to persist for much longer than a few hours. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Indentations on sea bed left by vessels (vessel jack-up and anchoring operations).	Up to 6 legs of a jack-up barge. Each leg will have a maximum diameter of 16m and form footprint between 50 – 200m^2. Penetration	• Conceptual understanding of potential impact	As each leg is inserted it will cause the already partially consolidated sediments to be compressed downwards and displaced laterally. This may cause the sea bed around the inserted leg to be raised in a series of concentric pressure ridges. As the leg is retracted, some material that has

Phase	Potential Impact	WCS Details	Assessment Method	Assessment of Effect
		will be between 0.5 – 3m into the bed. Anchor arrays (of 4 – 6 no. anchors) will typically be smaller than jack-up barge legs		previously been displaced will avalanche back into the depression until a maximum stable slope angle is achieved. The pits will infill under tidally-driven sediment transport, probably over a timescale of months to years. For anchors, anchor scars will be created in the sea bed. These will become reworked and flattened to a baseline conditions by the action of tidal currents over a few tidal cycles. Significance of impact on receptors = **Not significant**
Construction and Decommissioning	Disruption to coastal morphology at cable landfall.	Horizontal Directional Drilling (HDD) at landfall at Bawdsey.	• Conceptual understanding of potential impact	Minimal direct disturbance is caused by HDD and the construction programme for this activity is relatively short in duration (up to a few months). Significance of impact on receptors = **Not significant**
Operational	Changes to the tidal regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	• Numerical modelling using Delft3D-FLOW • Existing evidence base from other wind farms • Conceptual understanding of potential impact • Interpretation against baseline tidal current values (typically 1.15 – 1.25m/s on peak spring tides) •	No measureable change in water levels (maximum modelled change is 0.007m). Localised flow accelerations around the foundations and wake effects downstream of the foundations (within up to a few hundred metres downstream). Maximum reductions modelled in the range 0.05 – 0.1m/s within the array. Maximum increases modelled to be 0.05m/s within the array. Only very minor changes in flow direction (<5°). Significance of impact on receptors = **Not significant**
Operational	Changes to the wave regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	• Numerical modelling using Delft3D-SWAN • Existing evidence base from other wind farms • Conceptual understanding of potential impact • Interpretation against baseline wave climate values (typically H_s = 0.5 – 1.0m and T_m = 3.5 – 4.0s) •	Maximum reductions in wave height appear within, or along the boundary of, the array. These may reach up to 20% during large storm events within the array, but under typical conditions reductions are less than 2% at a distance of 40km from the array. There is no measureable effect on wave conditions at the shore. Significance of impact on receptors = **Not significant**
Operational	Changes to the sediment transport regime due to the presence of the foundation structures.	Array of WTGs founded on GBS	• Outputs from numerical modelling using Delft3D FLOW and SWAN • Standard empirical equations (mobilisation and settling of sediment particles) • Existing evidence base from other wind farms and industry guidance (Kenyan & Cooper, 2005) • Conceptual understanding of potential impact • Interpretation against baseline sediment transport regimes	Local changes in tidal current and wave regimes may induce scour. The broader bedload and suspended sediment transport regimes will be largely unaffected as chnages in tidal and wave regimes are so minor. Similarly, there will be no change in the sediment transport regime at the shore. Significance of impact on receptors = **Not significant**
Operational	Scour effects due to the presence of the foundation structures, resulting in erosion, re-suspension and settling of sediments.	Jackets (no scour protection planned) and GBS (scour protection provided) both considered.	• Outputs from numerical modelling using Delft3D FLOW and SWAN • Standard empirical equations (empirical scour formulae) • Existing evidence base from other wind farms	Scour hole development will occur around individual legs of a jacket, and group scour under the jacket may also occur. With scour protection provided, no scour will occur around the GBS. Significance of impact on receptors = **Not significant**

Phase	Potential Impact	WCS Details	Assessment Method	Assessment of Effect
			• Conceptual understanding of potential impact • Interpretation against baseline variations in sea bed levels	
Operational	Scour effects due to the exposure of inter-array and offshore cables and cable protection measures.	Cables buried along entire length.	• Standard empirical equations (empirical scour formulae) • Existing evidence base from other wind farms and industry guidance (BERR, 2008) • Conceptual understanding of potential impact • Interpretation against baseline variations in sea bed and shore levels	Scour of any exposed cable lengths to a depth of 1 – 3 times the cable diameter (i.e. 0.1 – 0.7m) and across an area of sea bed 50 times the cable diameter (i.e. 4.5 – 12m). Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia ONE construction (including offshore cable installation) and construction of other wind farms.	Consideration of any other wind farms located within one spring tidal excursion ellipse from the East Anglia ONE OWF	• Agreement reached with regulators during scoping and consultation phases. • Conceptual understanding of potential impact • Interpretation against baseline tidal excursion ellipses.	No other wind farms are located within a distance of one spring tidal excursion ellipse from the East Anglia ONE OWF. Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia ONE construction (including offshore cable installation) and installation of other offshore wind farm offshore cables.	Consideration of any other wind farms' offshore cables being installed at the same time and located within one spring tidal excursion ellipse from the East Anglia ONE OWF	• Agreement reached with regulators during scoping and consultation phases. • Conceptual understanding of potential impact • Interpretation against baseline tidal excursion ellipses.	No other wind farms' offshore cables are being installed at the same time and are located within a distance of one spring tidal excursion ellipse from the East Anglia ONE OWF. Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia ONE construction and marine aggregate dredging.	Consideration of any marine aggregate dredging located within one spring tidal excursion ellipse from the East Anglia ONE OWF	• Agreement reached with regulators during scoping and consultation phases. • Conceptual understanding of potential impact • Interpretation against baseline tidal excursion ellipses.	No marine aggregate dredging sites are located within a distance of one spring tidal excursion ellipse from the East Anglia ONE OWF. Significance of impact on receptors = **Not significant**
Cumulative Effects	Changes to the current regime as a result of the combined activities of East Anglia ONE operation and bed level changes from marine aggregate dredging.	Changes in current speed arising from an array of WTGs founded on GBS	• Outputs from numerical modelling using Delft3D FLOW • Conceptual understanding of potential impact	Changes in current flow speeds do not extend to marine aggregate dredging areas. Significance of impact on receptors = **Not significant**
Cumulative Effects	Changes to the wave regime as a result of the combined activities of East Anglia ONE operation and bed level changes from marine aggregate dredging.	Changes in wave regime arising from an array of WTGs founded on GBS	• Outputs from numerical modelling using Delft3D SWAN • Conceptual understanding of potential impact	Changes in wave regime essentially oppose potential changes from marine aggregate dredging. Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia ONE offshore cable installation and marine aggregate	Consideration of any marine aggregate dredging located within one spring tidal excursion ellipse from the East Anglia ONE OWF and offshore cable	• Outputs from numerical modelling using Delft3D FLOW and SWAN • Existing evidence base from marine aggregate dredging industry (including	Cumulative plumes may potentially cover a slightly larger geographical area and, for a very short period of time, locally exhibit higher concentrations than assessed for each operation individually. However, this higher concentration plume would be expected to persist for a short duration only.

Phase	Potential Impact	WCS Details	Assessment Method	Assessment of Effect
	dredging.		East Anglia MAREA) • Conceptual understanding of potential impact • Interpretation against baseline variations in sea bed levels	Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction of sediment plumes as a result of the combined activities of East Anglia ONE construction (including offshore cable installation) and disposal of dredged material.	Consideration of any dredge disposal activities located within one spring tidal excursion ellipse from the East Anglia ONE OWF and offshore cable	• Agreement reached with regulators during scoping and consultation phases. • Conceptual understanding of potential impact • Interpretation against baseline tidal excursion ellipses.	No dredge disposal sites are located within a distance of one spring tidal excursion ellipse from the East Anglia ONE OWF. Significance of impact on receptors = **Not significant**
Cumulative Effects	Interaction between East Anglia ONE wind farm and other wind farms in the region, causing a change to the hydrodynamic regime and associated changes in sediment transport.	Array of WTGs founded on GBS	• Outputs from numerical modelling using Delft3D FLOW and SWAN • Existing evidence base from other wind farms • Conceptual understanding of potential impact • Interpretation against baseline tidal current and wave regimes	Magnitude of change in hydrodynamic regime from East Anglia ONE is negligible and therefore there is no potential for interaction with other wind farms in the region. Significance of impact on receptors = **Not significant**

7.1.3 Minutes from First Physical Processes Expert Topic Group Meeting

EAOW Round 3 Offshore Programme East Anglia THREE & FOUR, Physical processes ETG Meeting 1				
Date of Meeting:	13.09.2013	**Venue:**	Tudor Street	
Attendees				
Name	**Initials**		**Organisation**	
Keith Morrison	KM		EAOW	
Claire Ludgate	CL		Natural England	
Siobhan Brown	SB		Natural England	
Holly Drake	HD		Cefas	
Dean Foden	DF		Cefas	
Paolo Pizzolla	PP		Royal HaskoningDHV	
Nick Cooper	NC		Royal HaskoningDHV	
Document Ref:		**Issue Date:**	17/9/13	
13:30 – 15:30				

ITEM	DESCRIPTION	ACTION
1	Health & Safety matters were introduced by KM	
2	Introduction - KM introduced the background to the projects in the East Anglia Zone. (slides 3- 8) PP presented the evidence plan expectations to explain process to those previously not involved in the process and the expected timeline for how the process will work for physical processes (slides 9 – 12) NC outlined that changes in physical processes are ‘effects’, which manifest in terms of impacts on other receptors, such as benthic/fish NC stressed the need for proportionality within the assessment and need to maximise value of previous work done for the Zone and for East Anglia	

ITEM	DESCRIPTION	ACTION
	ONE	
3	Data for the assessment – (refer to background paper sections 2.1.1 – 2.1.3) The assessment will be based on: full geophys of East Anglia THREE and East Anglia FOUR sites , existing data sets for cable route from East Anglia ONE and geophys 'gap filling' for cable route for those parts not surveyed for East Anglia ONE (slide 13) Site specific metocean data being collected and incorporated into assessment in batches (slide 14) Data collected from across the Zone will be used for PSA, again those areas not included in previous surveys (e.g. those parts of the cable route in the deep water channel) were captured by fill-in survey from 2013 The assessment will utilise existing Zone and East Anglia ONE data and analysis for context NC listed the large number of regional physical process studies to feed in as context (see para 12 & 13 of background paper) In addition there is now a large number of OWF modelling studies and monitoring reports to feed in to the assessment as context	
4	Assessment of effects NC - Although there may be changes in physical environment the key is how these translate in impacts upon receptors (i.e. benthos and fish) – therefore the assessment techniques used should be proportionate to the impacts upon receptors The effects to be assessed are listed in background paper sections 2.1.4 for offshore, section 2.2. for coastal Given the comparison of worst case scenarios (see background paper Table 2) and shared geography it was considered reasonable that work undertaken for Zone and East Anglia ONE would be directly relevant for of East Anglia THREE and East Anglia FOUR	
5	Methodologies NC worked through the proposed methodologies for each effect for the offshore assessment (see background paper Table 3)	

ITEM	DESCRIPTION	ACTION
	Cefas and Natural England happy with expert judgement approach (i.e. no need for site-specific modelling) – subject to internal discussion with receptor experts (i.e. benthic and fish) Operational effects – draw from evidence base for wave/tidal effects DF - East Anglia THREE and East Anglia FOUR – some parts are shallower than East Anglia One – will need to account for that – also need to identify areas of impact as a 'box' around each array to demonstrate no far field effects. This can be expert-based assessment. Scour – empirical assessment still needed for all foundation types that will be considered. It is not only plumes arising from scour, but also footprint of any scour protection material that needs consideration. DF - What if assessment suggests plumes from each project area interact? NC - Unlikely that projects will be built together – little chance of this occurring in practice Coastal/landfall assessment see background paper section 2.2)– the aim is to re-evaluate the East Anglia One assessment (which shares a common landfall corridor with East Anglia Three and East Anglia Four) based on timing of construction works. There are likely to be three separate construction events within the corridor; one for the landfall of each offshore cable Cable burial – will use a figure of up to 10% of cables needing protection subject to further studies refining this. Natural England and Cefas both happy to be involved in further discussions on method if necessary following availability of further engineering details.	NC to amend Table 3 in light of today's discussions and circulate for sign-off

ITEM	DESCRIPTION	ACTION
	This will be particularly required if cable burial is not possible in shallower areas, where effects on littoral transport processes could be caused. If cable burial is not achieved in deeper areas, then expert based assessments will suffice. Cable crossing – will need further consideration of type, location and extent of protection works concentrated at cable crossings. Cumulative Proportionate and high level assessment will suffice given the extensive work that has already been undertaken for Zone Cumulative Impacts and East Anglia One.	

ID	Issue on which EAOW THREE and FOUR seek agreement on	Agreed Position
1	Sufficient survey data (extent/duration) has been collected to undertake the assessment	Agreed
2	The list of potential physical process effects to be assessed are as proposed in the Evidence Plan method statement	Agreed
3	Agreement of the proposed methodology for each impact	Agreed in principle that there is no need to model plume/sediment deposition, assessment will be expert judgement based upon knowledge of sites and available contextual information (in particular Zone and East Anglia ONE studies and modelling) Method statement will be updated in light of discussions from this meeting and circulated for sign-off

7.1.4 Emailed Agreement on Minutes of ETG 1

4. Cefas

From:	Holly Drake (Cefas)
To:	Pizzolla, P. (Paolo)
Cc:	Rebecca Walker (Cefas); Mongan, Kathleen (MMO); Dean Foden (Cefas)
Subject:	RE: East Anglia 3 & 4 - Evidence Plan Expert Topic Group - Physical Processes
Date:	01 October 2013 14:31:49
Attachments:	image001.png image002.jpg

Hi Paolo,

I'm content that the minutes are accurate and that the points we raised have been addressed in the updated paper. I can also confirm that I'm content with the non-modelled approach for suspended sediment as there are no sensitive receptors that can be potentially impacted upon.

Kind Regards,
Holly

5. Natural England

From:	Ludgate, Claire (NE)
To:	Pizzolla, P. (Paolo)
Cc:	Tarrant, D.C. (David)
Subject:	FW: East Anglia 3 & 4 - Evidence Plan Expert Topic Group - Physical Processes
Date:	10 October 2013 15:54:11
Attachments:	image004.png image001.png

Hi Paolo,

Natural England have now reviewed the meeting minutes and are satisfied they are accurate.

We have also reviewed the updated Physical Processes Method Statement and I can confirm we are satisfied that the comments raised at the meeting have been incorporated and are happy with the changes and proposed approach.

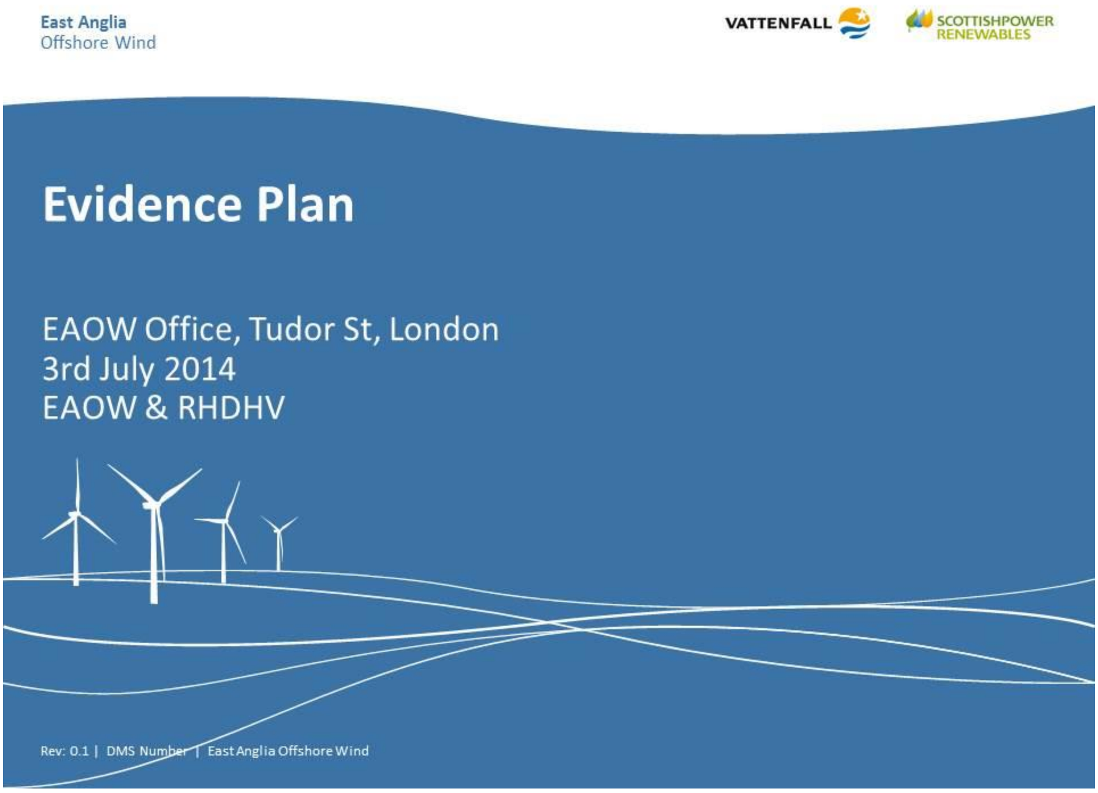
Many thanks,

Claire

Claire Ludgate
MSc AMIMarEST

Marine Lead Adviser
Southern North Sea Team

7.1.5 Presentation Given at Physical Processes ETG Meeting 2 3rd July 2014



East Anglia
Offshore Wind

Background

- Chapter and technical appendices:

Royal HaskoningDHV
Enhancing Society Together

- Technical surveys and studies from:

Cefas · Deltares (Enabling Delta Life) · Fugro EMU · GEMS · MES

- Supported by previous modelling for East Anglia ZEA and East Anglia ONE:

ABP mer (marine environmental research)

- Physical Processes Background Paper and meeting

Natural England · Cefas

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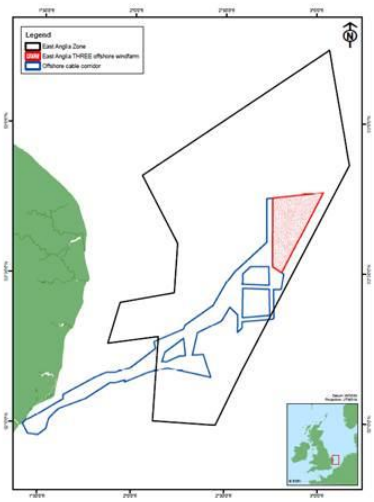
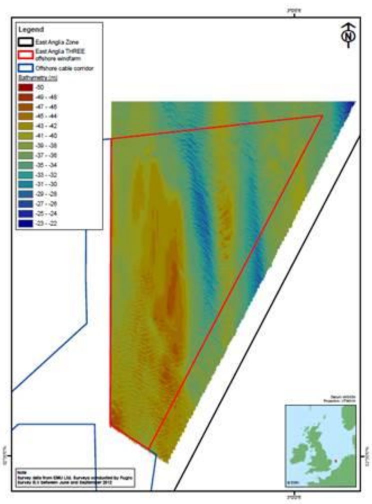
East Anglia
Offshore Wind

Baseline





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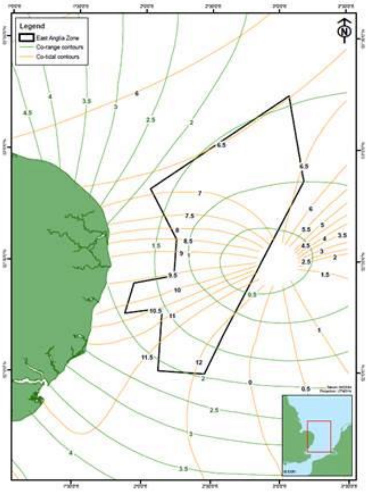
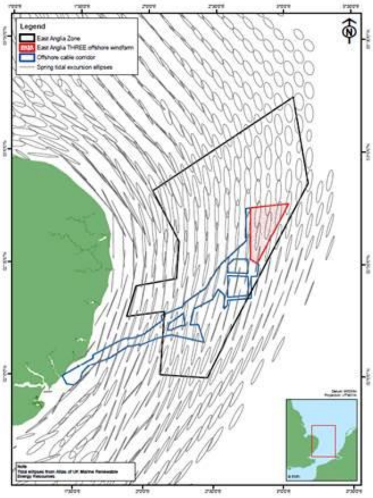
East Anglia
Offshore Wind

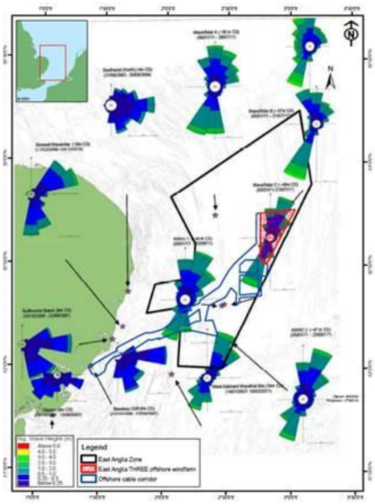
Baseline

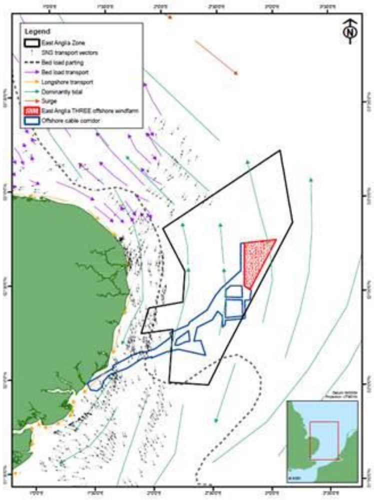




East Anglia
Offshore Wind

Baseline





East Anglia
Offshore Wind

Impact Assessment

- Worst case scenario(s)
  - Layout and numbers of turbines
  - Type(s) and size(s) of foundations
    - Blockage effects (waves, tides, sediment transport)
    - Sediment disturbance effects (sea bed sediments, sub-surface sediments)
  - Met masts and monitoring buoys
  - Offshore platforms
  - Inter-array cables
  - Offshore export cable corridor
  - Cable laying
    - Methods
    - Cable protection
  - Cable landfall

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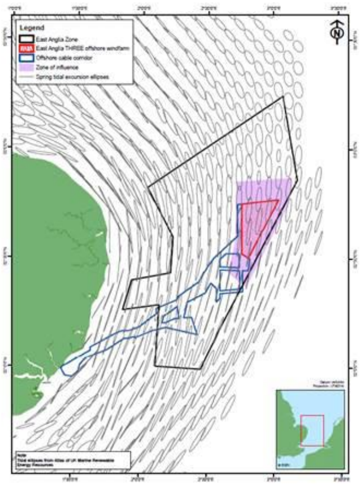
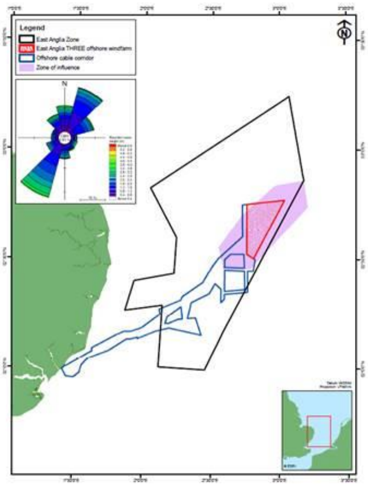
East Anglia
Offshore Wind

Impact Assessment





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East Anglia
Offshore Wind

Impact Assessment

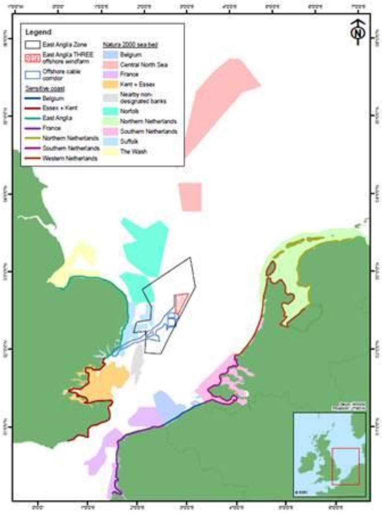
- Magnitude of effect (near & far field)
- Sensitivity of receptor (if affected)
- Impact assessment
- Confidence statement

- Geological / geomorphological receptors
  - Tidal ellipses
  - Wave direction(s)
  - Sediment transport direction(s) and mechanism(s)

- 'No impact' (mostly)
- Impacts of 'negligible' significance (export cable installation, cable landfall installation)
- Impact 'minor' significance (export cable protection)

- Effects could have impacts on other receptors (addressed in other chapters of PEIR)

- No significant cumulative impacts except for minor cumulative (cable protection)



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East Anglia
Offshore Wind

Any clarifications required?

- *Are there any areas which require clarification on?*
  (If possible please provide details in advance of the meeting).

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East Anglia
Offshore Wind

Any outstanding issues?

- *Are there any areas that you believe to be outstanding?*
  (If possible please provide details in advance of the meeting).

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East Anglia
Offshore Wind

Updates since PEIR

- *The up to two Interconnection with East Anglia ONE have only been assessed up to the point at which they would pass into the East Anglia ONE site boundary.*
- *Further work is ongoing to work out where the interconnectors would connect into East Anglia ONE*

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7.1.6 Minutes from Physical Processes ETG Meeting 2

East Anglia Offshore Wind Limited East Anglia THREE

East Anglia THREE, Marine PEI/Evidence Plan Meeting – 03/07/14

Attendees		
Name	**Initials**	**Organisation**
Mandy Gloyer	MG	EATL
Kathy Wood	KW	EATL
Jesper Kyed Larsen	JKL	EATL
Lou Burton	LB	Natural England
Francesca Shapland	FS	Natural England
Kathleen Mongan	KM	MMO
Holly Drake	HD	Cefas
Dean Foden	DF	Cefas
Paul Whomersley	PW	Cefas
Louise Cox	LC	Cefas
Paolo Pizzolla	PP	Royal HaskoningDHV
Beth Mackey	BM	Royal HaskoningDHV
Nick Cooper	NC	Royal HaskoningDHV
Apologies		

AGENDA		
Item	**Description**	**Action**
1	Health and Safety Introductions - All	n/a
2	**Project update**	
3	**Physical processes**	
	Approach NC – short presentation on methodology and results, no significant impacts upon any of the identified sensitive receptors LB – assessment as expected, NE have provided some comments on areas of clarification *Zone of influence* DF – highlighted that the zone of influence does not cover the NW corner of EA3 NC – as there are only a few turbines in the corner there is a lack of interaction between turbines (there would be greater potential for influence in areas where more turbines are grouped and therefore 'shadowing' can occur) therefore limited effect on with waves/currents at this point	ACTION – NC to phone DF to explain fully; EATL will alter the figure to show that there is some effect in the NW corner of the site
	Point 44 – seabed levelling LB – where are areas which may require levelling? Are these inshore	ACTION – clarify in text areas where levelling may be likely

	KW – levelling is intended only to prevent exposure of cables and spanning. NC – within OWF foundations will not be constructed in areas of sandwaves >5m, larger sand waves are largely offshore and to the south	
	Point 45 – cable crossings and protection LB – NE question the worst case assumed for cable protection and request greater clarity on how the percentages of protection were derived. KW – figures came from known cable crossing plus some level of precaution. EATL can provide more narrative on how these figure were decided PP – height of protection based on worst case of a pipeline crossing, cable crossings would be lower NC – have incorporated this in assessment, the assessment shows that these percentages of cable protection do not create significant impacts. Of particular importance is any protection inshore of the closure depth.	ACTION –greater clarity and evidence of rationale to be presented in the ES, cable protection note to be included as appendix – include the design of cable protection – including explanation of typical areas of up to 4m height
	Point – 46 – landfall LB – NE require clarity on the ramp at the landfall and exit points for short HDD option. We should follow the position reached on EA1 PP – ramp required under short HDD (Scenario 2) and under Scenario 1 in event that cable jointing is in the shallow subtidal. The ramp would be away from Red Crag feature (this feature is outwith the red line boundary). Cables will be buried to prevent exposure and no cable protection (i.e. rock dump or mattressing) is planned in the intertidal or close to the shore. NC – There would only be temporary works in the intertidal. Projections on foreshore lowering done by ABPMer – they represent long term rates of change – encompass events such as the 2013/14 winter storm events. The cable will be buried taking into account these projections.	ACTION – LB to provide her note on the landfall (SB's expert report and NE written summary)
	Point 29 – WCS scour from WTG foundations NC – unlikely to get a refined design for smaller GBS for 7MW WTGs, therefore will assume largest size and multiply up to 172. This will still not be a significant impact	ACTION – update assessment for 172 60m GBS. Add narrative to explain worst case
	Point 28 – spoil disposal KW – EATL will be putting together site characterisation report to cover disposal. This will be separate document from ES. There will be a separate consultation on this document.	ACTION – site characterisation report to be produced and consulted upon.
	Point 37 – temporary work areas NC – temporary work areas not in the chapter, assume	ACTION – amend assessment to

	this to refer to impacts of vessel anchors/feet in construction and operation. The scale is such that it is not significant KW – agreed maintenance figures with MMO for EA1, these should be clarified in project description and assessment for EA3	cover these impacts (operational impact 9)
	Conclusions Some clarification of the project description required to help with the understanding of the assessment – in particular cable protection, WCS scour, landfall, spoil disposal	
7	**All topics**	
	Agreement log LB – NE cannot sign off on conclusions of the assessment, this can only be done once the DCO is submitted. The agreement log is welcome as an indication of what will be covered by the SoCG *Project description* There are areas of the project description – particularly in relation to duration of individual activities – which could be better defined to improve understanding of the impacts *In principle monitoring plan* NE would welcome the inclusion of an in-principle monitoring plan within the DCO covering offshore topics. This would be high-level rather than prescriptive. This would be referred to in the DML conditions. In particular this would be worded to allow for alternatives to site-specific monitoring to be used to discharge licence conditions.	ACTION – circulate agreement logs for information only

7.1.7 S42 Consultation with Natural England on the PEIR

6. Following Phase IIa consultation under section 42 of the planning act (see the Consultation Report, submitted as part of this application for further detail). Natural England provided comments on Chapter 7 of the PEIR. In order to discuss these comments and agree a resolution a meeting was held on the 3rd of July 2014 under the auspices of the Evidence Plan. The table below details the individual comments and provides the revised position on each comment following the meeting.

7. The comments are summarised in Chapter 7 Marine Geology, Oceanography and Physical processes *Table 7.1*.

8. Natural England also provided comment on the draft Environmental Statement Chapter 7. These comments are included within *Table 7.1* of Chapter 7.

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
Chapter 7 Marine geology, oceanography and physical processes					
23					*<u>General updates from workshop:</u>* Approaches discussed last October. Dean (CEFAS) and Siobhan (NE) provided feedback then and it is hoped that many issues have now been resolved.
24			RH	NB: Intertidal and near shore zone would need further discussions; as would the cable crossings as and when the info becomes available as a full assessment isn't yet available.	It was agreed that this would be confirmed in the final ES
25	33	p.9 (also in sections 22 (p.42), 229 (p.47) & 236 (p.48); Ch 5 sections 5.4.4.1.4 (p.14) & 5.4.4.2.2 (p.17)) 7.3.2.6	RH	Natural England notes that a full assessment of the disposal material has not been considered in the case of drill arisings. Natural England expects to see further information to be included such as the locations and methodology predicting the expected behaviour.	Construction Impacts No. 1 in chapter drill arisings has been assessed. Impacts No.2 is changes in seabed level. Split that down. Worst case scenario SSC realised from hammer barge into the water column. Plume and bed deposits are considered. They would be released at each pile location and into the water column. Clasts would bottom out quicker. Requirement to get the site reclassified as a disposal site. A document will be provided on this which pulls together all of the information within the final ES.
26	46	p.12 Para 323	RH	NE questions whether the WCS for scour has been fully assessed. The assessment is for 100 x 12 GBFs across the site. However there could be up to 172 foundations if smaller foundations (7MW) were more appropriate to use. The cumulative impact	This was discussed at the workshop and 100 turbines across the site were modelled. Model assessment considered a range of different types of foundation.

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
				across the site would likely be greater for a larger quantity of smaller foundations than for a lesser quantity of larger foundations. Natural England acknowledges that the size of foundation will be dependent on water depth but notes that in point 40 (page 10) that it is stated that 80% of the site is 35-45m in depth. Natural England also notes that the conical gravity base structures have been considered as the worst case for this depth hence the diameter size at 55m but Natural England would like further clarity that the WCS has been fully considered. Is it appropriate to assume that the WCS would be 100 conical gravity base structures with a diameter of 55m at a depth of (35-45m) for the entire site and not consider a larger quantity of smaller foundations in the shallower areas (also applies to the opposite in areas of greater depth with fewer larger foundations)? Is it appropriate to just use a blanket approach across the site and not estimate more accurately based on water depth?	GBF are considered the worst case scenario for scour. Within the deeper water zone, increases the diameter of foundation by 5m result in considerably less scour. As the combination of currents and waves influence the scour within the deeper water you get less scouring at the base. Agree that this would be better to assess what could be built if constructed now i.e.7m Gravity based for 172 turbines and included with some rationale behind assessment. To be included within final ES. Should technologies evolve between now and construction then it was agreed that an assessment would need to be undertaken at that time to either demonstrate that the impacts are within the Rochdale Envelope assessed or that an amendment to any consent would need to be applied for.
27	69 & 71	p.15-16	RH	Natural England notes that cable protection would reach heights of up to 1-3m and 1-4m above the seabed for inter array cables and cable crossings, respectively. It would be helpful if the detail behind these estimations were provided.	Further clarity will be provided by the engineers on this and will be included within the final ES.
28	74	p.16	RH	The hierarchal approach to selecting the most appropriate cable protection in order to reduce impacts to sensitive receptors is welcomed by NE. When will this be determined and presented?	To be considered further in the ES and/or reference made to the Cable Burial Management Plan marine licence

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
					condition, where this will also be considered
29	P.23	53 (also in sections 414 (p.80), 382 (p.75) and 383 (p.75); Ch10 section 10.7.2 (p.84). 7.3.2.6	RH	The max of 4 cables plus the three crossing cables of the proposed Galloper and the three from Greater Gabbard = 24 cable crossings. Natural England query whether the impacts of this have been fully assessed in relation to increased scour, marine physical processes and benthic impacts. In relation to the cumulative impacts of the cable crossings/ export cable protection in relation to the Suffolk Natura 2000 and East Anglia Coastline Natural England question whether a more defined estimate can be provided in order to ensure a thorough assessment of impact.	Discussion on the areas of cable corridor that are common to both projects. Both cable corridors join as they leave the EA Zone. Cable crossing Gabbard and Galloper. Agreed that the maps would be adjusted within the project description to show the difference. Inter connections should go to the edge of EA ONE and to be clear only for EA3 and 1 and not as a hub for all projects. Lengths of cables will be a minimum.
30	P.59-61	300-310	RH	Natural England questions whether a full assessment of the WCS has been carried out when considering the changes to suspended sediment concentrations and coastal morphology at the offshore cable landfall. Has the potential interruption to sediment transport been considered during the construction phase? Although it is reported that HDD techniques will be used to install the cables will there be any need for cofferdams in the intertidal area during construction?	Confirmation of Impacts assessment: Morphological receptors that could be potentially impacted have been fully considered. Suffolk coast is considered a principle area for further consideration. No impacts 'mostly' Impacts of 'negligible significance' from export cable installation and landfall installation – and cable protection works along the export cable. No significant impacts in--combo or trans-boundary.
31	p.63	318 & 323	RH	When considering the worst case changes in terms of the tidal regime due to the presence of largest foundations the frequency is assessed as medium. Natural England questions whether this	Confirmation was provided in the workshop that the tidal zone in the array is very low. Tidal movements are on N-S

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
				appropriate considering that the foundations will be present as a constant throughout the lifetime of the project. This change in frequency may alter the overall magnitude of effect from low to moderate?	axes. Wave direction predominantly NNE direction. Sediment transport is to the North. Closer to the shore it is the opposite. CEFAS raised point about Slide 8 of the workshop presentation and that the NW corner of the array was not shown on the figures. Agreed that the whole array should be included. Haven't shown the Rochdale envelop of the impacts. The reason NW not included was on the edge there are minimal impacts from a few turbines so therefore they are excluded from, the zone of influence. Still believe that there is no impact to coastal processes. And that the assessment is proportionate. Zone of influence included. Mapped from previous modelling +/- 5% the change will be so small in NW corner that it is below the 5% of influence. But it was agreed to include anyway in the ES to aid clarity
32	P.69	350	RH	Natural England questions whether temporary works areas have been included when considering the total impacts of scour around foundations in the total worst case scenario footprint both here and throughout the rest of the assessment. Only turbine foundations, meteorological masts and offshore	Turbines, platforms, met masts etc. have been considered as temporary works. However, Footprints of Jack Up barges are not included in operation phases but should be under maintenance activities.

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
				converter foundations look to have been considered.	Maintenance will be fully covered in the chapter too.
33	P.70	354	RH	Natural England queries the conclusion that there will be no impact from the presence of foundation structures associated with the proposed project on the identified marine geology, oceanography and physical processes receptor groups when the magnitude of effect is assessed as being high. Natural England acknowledges the possibility of using scour protection and that the total footprint will not be the entire project area, but the use of scour protection should be minimised as much as possible.	This was not discussed at the workshops, but Natural England would welcome wording with the ES that would support minimising the use of scour protection
34	P.70	355	RH	In relation to the impacts to other receptors, although Natural England notes that the impacts will be discussed further in the other relevant chapters of the PEIR; we advise that it would be helpful to at least list and signpost to the discussions. This would help ensure clarity when considering indirect impacts to other receptors. This applies to this section and throughout the	This point was recognised in our discussions at the workshop and noted by EA3.
35	P.70	356	RH	Natural England notes that while there is an assumption that only 10% of the inter-array cables and a further 10% of the offshore export cables (in relation to cable crossings) will be surface laid requiring additional protection, can a further footprint be estimated based on this percentage to provide further clarity as to the total quantity that will be required to help inform the assessment.	It was agreed that this information would be available in the final ES
36		7.3.2.7	SB (MAJOR)	Section 7.3.2.7- Cable laying states "*In some areas, where large sand waves or mega ripples are present, sea bed levelling may first be required before the cable can be installed*". Further information is needed on where these sand waves may be	It was confirmed in the workshop that large sand waves are not believed to be in the inshore area. This should be clearly presented in the ES

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				cleared, i.e. are these sandwaves located closer to the coast and may therefore have a wave breaking function?	Confirmed that only levelling of shallow sandbanks is anticipated. Clarified that Norfolk banks (to the north) and those slightly further south have the wave breaking effects Agree that further clarity would be provided in the text of the final ES to explain the above.
37		Para 71 & 368	SB (MAJOR)	Paragraph 71 notes "*For the purposes of a worst case, it has been assumed that up to 10% of the export cables within the offshore cable corridor would be unburied and require protection in locations that are to the east of the cable crossings and that up to 2.5% of the export cables would require protection in locations to the west of the cable crossings. The height of cable protection measures from the sea bed would range from 1m where burial of the cable is not possible due to ground conditions to up to 4m where East Anglia THREE offshore export cables cross other infrastructure (such as cables and pipelines).*" Where did these figures of potential cable protection come from? Paragraph 72 notes "The worst case values used in the assessment are intended to allow for flexibility within the DCO and are based on recent practical experience of cable installation which demonstrates that achieving 100% burial is not always possible." Why have these figures therefore been chosen? It would be useful if any text of this detailed in the appendices could be added here. The approach for how to deal with cable protection outlined in paragraphs 73 and 74 is welcomed but a little more explanation for the percentage figures and likelihood of cable	Number of cable crossings and areas of hard ground are to be clarified in the ES Consideration of cable protection was based the figures on a suitable level of precaution as don't have geophysical and geotechnical data to support it. This should be provided as part of the current EA ONE investigations Agreed that a technical note will be provided in the final ES to clarify where the figures have come from. Sediment transport to shore reduces the further you go offshore. Further offshore there are tidal currents only. Closure depths – have been calculated within the near shore zone and inshore of the cable crossings. Hence the agreement to limit cable protection to beyond the cable crossings.

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				protection being required in the nearshore would be useful.	
38		Para 76 Section 304	SB (MAJOR)	Paragraph 76 notes "*At the landfall, the offshore export cables would be installed to depths of 3 to 10m below the sea bed and under the existing coastal defences. It is anticipated that the horizontal directional drilling (HDD) technique, or similar, would be used and open trenching would only be used where there are no coastal defences and when it can be demonstrated that the impact is less than using HDD. There are two variants of the HDD method, a 'long' or 'short' HDD*." Have the 3 to 10m depths included foreshore lowering rates? The project description in chapter 5 notes that HDD will be used to limit any impacts on the SSSI features of Bawdsey cliffs, so clarity around which option will be used is required. Although this section notes that short and long HDD methods are available there is no quantitative indication of how far offshore the short HDD option will go. Will it be entirely through the intertidal? Does this result in a risk that the cable will become exposed and potentially interrupt processes operating in the nearshore area? This is also relevant to later sections.	Associate development through EA ONE provides the facility to pull this through. Assess scenario two and further clarity within the ES will be provided. Interrupt the intertidal in the near shore area. Cliff recession. Landfall report is within the landfall and terrestrial chapter. Long term average rates of change, Agreed. NE to forward Expert Report and hearing summary for EA ONE to EA 3 – to discuss our thoughts on long and short HDD and use of ramp completed 03/07/2014
40		Para 114	SB (minor)	Paragraph 114 notes "*With regards to offshore cables, general UK practice would be followed, i.e. buried cables would simply be cut at the ends and left in situ, with the exception of the inter-tidal zone across the beach where the cables would otherwise be at risk of becoming exposed over time*." With regards to the intertidal zone, what does EA 3 consider this to be? Just the area exposed between tides or the whole "active" sea bed area where erosion may occur?	Clarification to be provided within the ES

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41		Para 217	SB (minor)	Paragraph 217 notes "*Indeed, the wave conditions across the East Anglia THREE site are more severe, suggesting that the passive plume would be similar or lower in concentration than that previously considered for East Anglia ONE*." I am not sure I understand why waves would result in less of a plume.	Clarification to be provided within the ES.
42		Para 225	SB (minor)	Paragraph 225 notes "*Due to the small quantities of sediment release involved, however, these disaggregated finer sediments are likely to be widely and rapidly dispersed, resulting in only low elevations in suspended sediment concentration and low changes in bed level when they ultimately come to rest on the sea bed*." Paragraph 227 notes "*This value is similar to the worst case volume that would be released from the jacket foundations that are being considered for the East Anglia THREE site (831m^3), with a similar distribution of envisaged sediment types at depth, but is acknowledged to be less than the worst case scenario for the monopile foundations being considered for East Anglia THREE (4,524m^3)*." Paragraph 228 states "*Nonetheless, the previous modelling results support the general principles of the expert-based assessments in that, away from the immediate release locations, elevations in suspended sediment concentration above background levels were low (<10mg/l) and within the range of natural variability*." How do these fit together? Is the worst case considered a low concentration? From a coastal process perspective we are content with the assessment on suspended sediment, it just depends on whether there are sensitive features nearby which we may have concerns about with regards to increases in suspended sediments.	As per point 34. In relation to the impacts to other receptors, although Natural England notes that the impacts will be discussed further in the other relevant chapters of the PEIR; we advise that it would be helpful to at least list and signpost to the discussions. This would help ensure clarity when considering indirect impacts to other receptors. This applies to this section and throughout the assessment. This point was recognised in our discussions at the workshop and noted by EA3.
43		Para 239	SB (minor)	Paragraph 239 states "*This assessment is supported by an*	To be considered by EA 3

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				evidence-base obtained from research into the physical impacts of marine aggregate dredging on sediment plumes and sea bed deposits." There is no mention of what this report does say so how does it support this assessment?	
44		Para 240	SB (minor)	Paragraph 240, over how wide areas were these very small increases in seabed felt? (This is only an issue if we have concerns that the depths presented could have an impact on habitats/species).	Further clarity would be helpful
45		Para 243	SB (minor)	Paragraph 243 notes "*Although the modelling used a smaller volume of material (982m^3 associated with jackets) than the worst case for the proposed East Anglia THREE windfarm (4,524m3 associated with monopiles) it does support the principles of the expert-based assessment that the envisaged scale of bed level change would be small*." Is the worst case for EA3 considered a small volume? How would this affect the previous changes to bed level predicted (4x as much?).	
56		Para 266 & 287	SB (minor)	Paragraph 266 notes with regards to construction of the export cable "*The offshore cable corridor is fully coincident with that of the proposed East Anglia FOUR project and the furthest inshore section and landfall is coincident with that previously assessed for the proposed East Anglia ONE project*." NE has struggled to find further information about exactly where this is co-incident with EA ONE. Are EA3 able to provide further information on this? Paragraph 287 notes that this may be at 15km offshore. This could be more usefully presented earlier in the document. Paragraph 287 "*The most inshore (15km) section of the offshore cable corridor is directly coincident with that for the proposed East Anglia ONE project and the section between this limit and*	

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				the boundary of the East Anglia Zone fully encompasses, and its width extends slightly beyond, that for the proposed East Anglia ONE project." So does this mean that the full cable route is within the EA ONE cable zone?	
49		Section 7.6.1.8	SB (minor)	Section 7.6.1.8, paragraph 300 notes "*Where the offshore cable makes landfall at Bawdsey in Suffolk, it must transit through the inter-tidal zone. It is presently envisaged that a horizontal directional drilling (HDD) technique, or similar, would be used*." Natural England notes conditions / working parameters where imposed upon EA ONE and the HDD ducts are likely to be installed for both EA ONE and EA3 and therefore these parameters should also be adopted by EA 3 should this project be built first or under scenario two	This was not discussed in the workshop, but we advise that this should be considered further in the ES
50		Para 308	SB (minor)	Paragraph 303 notes "*Consideration of final burial depths and shoreline set-back distances would be made during detailed design, based upon observations of past coastal change and projections of future coastal change, taking into consideration climate change effects (especially sea-level rise) during the operational lifetime of 25 years.*" NE notes that the project description chapter contains more detail on this and therefore reflected in this chapter.	This was not discussed at the workshop. But we would welcome further clarify within the ES
53		Para 324	SB (minor)	Paragraph 324 "*Due to proximity of the East Anglia ONE site to the 'non designated sandbanks' receptor group and also the Galloper Offshore Windfarm site, wave height reductions of up to about 5% were observed under the largest storm events considered at these locations.*" What will this mean for the sandbanks with this project in place? Could there be a cumulative impact with other windfarms? This does not appear to have been	This was not discussed at the workshop. But we would welcome further clarify within the ES

NE Point	Page	Section	Reviewer	Comment	NE Comments following workshop 03/07/14
				assessed.	
54		Para 352	SB (minor)	Paragraph 352 notes "*The precise need (or otherwise) for scour protection would be defined during the detailed engineering stages.*" What size would the scour protection be?	As previously highlighted it would be useful if the ES could provide further clarification on the scale of impacts to coastal processes
55		Para 354	SB (minor)	Paragraph 354 notes "*In the case of no scour protection being provided, the scour hole would respond dynamically to the prevailing tidal current and wave conditions, but the dynamic responses would be lower than magnitudes of natural change in sea bed levels*"	Clarify on the meaning of this statement would be helpful
57		Para 397	SB (minor)	Paragraph 397 states "*With regards to offshore cables, general UK practice would be followed, i.e. buried cables would simply be cut at the ends and left in situ, with the exception of the inter-tidal zone across the beach where the cables would otherwise be at risk of becoming exposed over time*." Would any length of cable through the cliff face also be removed?	To be clarified in ES and any decommissioning plan

Appendix 7.1 Ends Here